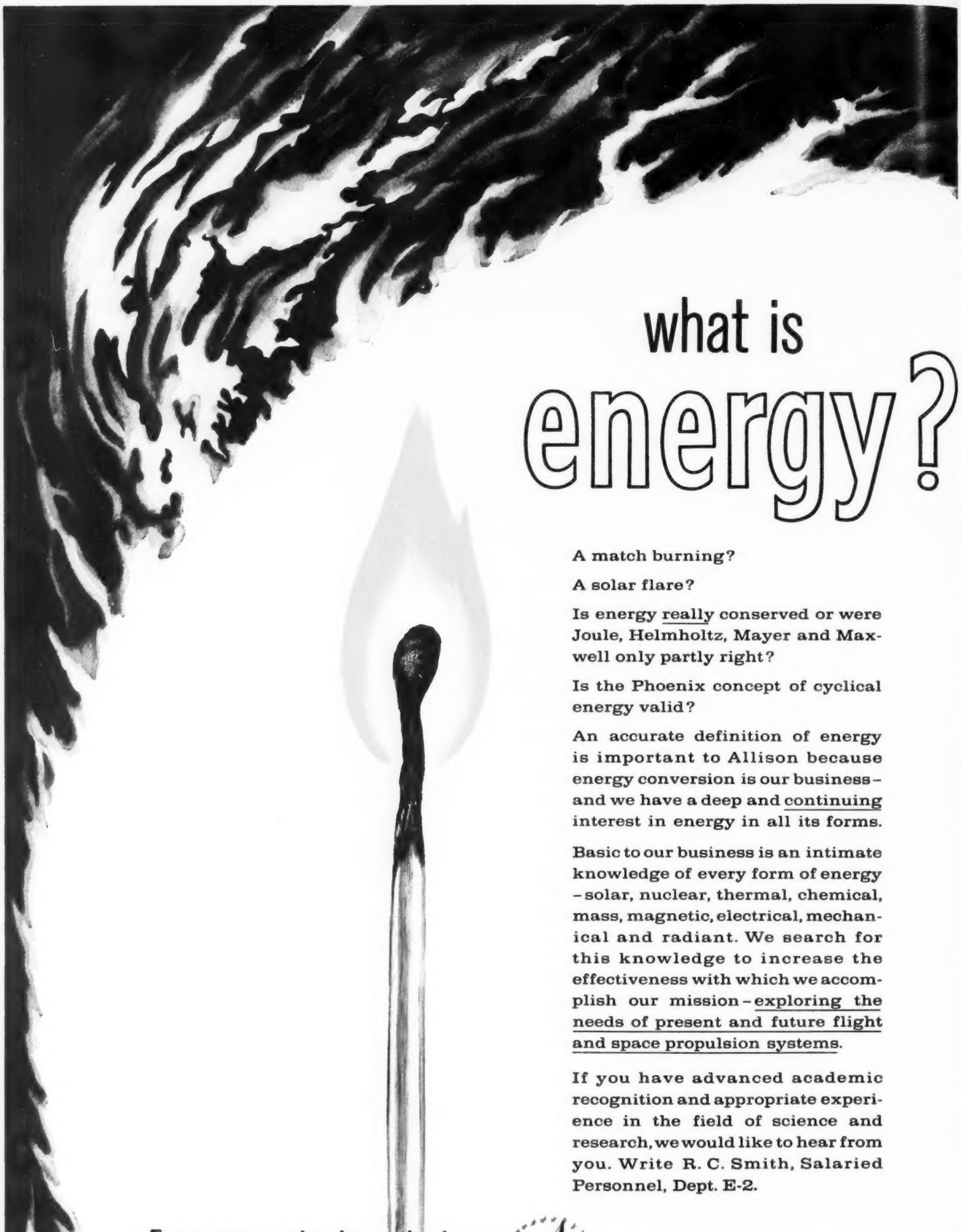
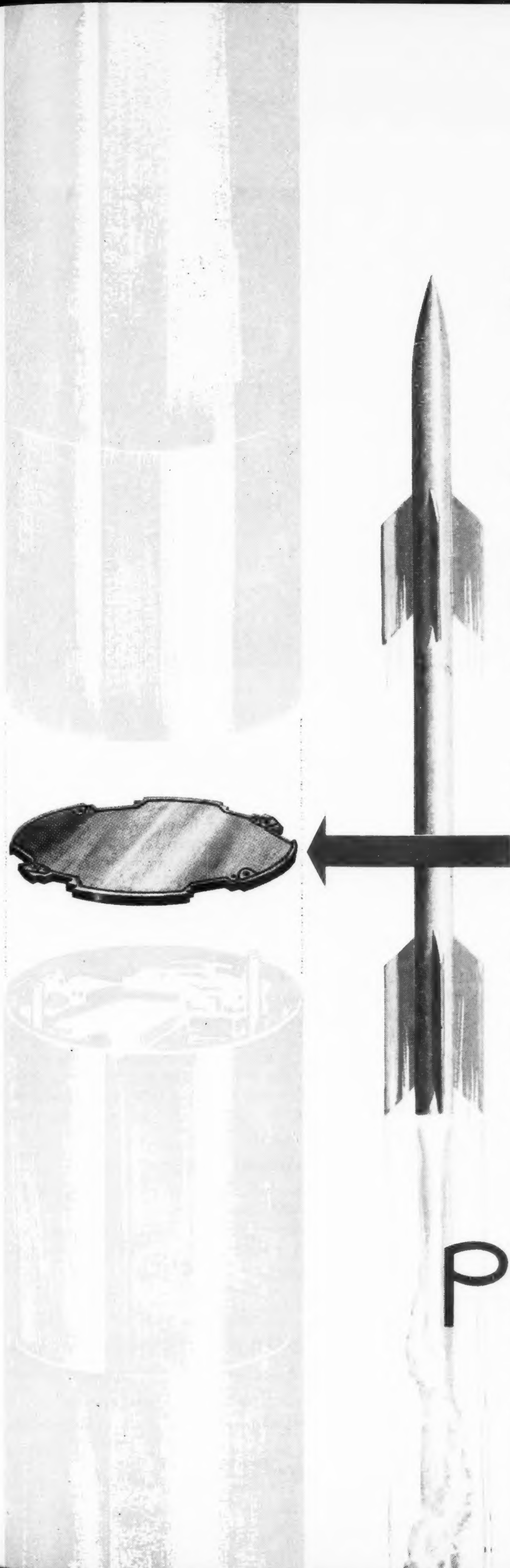
# Astronautics

A PUBLICATION OF THE AMERICAN ROCKET SOCIETY

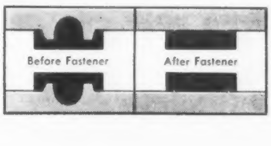
FEBRUARY 1959

**MAN IN SPACE —— THE HUMAN FACTOR**


what is
energy?
A match burning?
A solar flare?
Is energy really conserved or were Joule, Helmholtz, Mayer and Maxwell only partly right?
Is the Phoenix concept of cyclical energy valid?
An accurate definition of energy is important to Allison because energy conversion is our business – and we have a deep and continuing interest in energy in all its forms.
Basic to our business is an intimate knowledge of every form of energy – solar, nuclear, thermal, chemical, mass, magnetic, electrical, mechanical and radiant. We search for this knowledge to increase the effectiveness with which we accomplish our mission – exploring the needs of present and future flight and space propulsion systems.
If you have advanced academic recognition and appropriate experience in the field of science and research, we would like to hear from you. Write R. C. Smith, Salaried Personnel, Dept. E-2.
Energy conversion is our business
ALLISON
Division of General Motors,
Indianapolis, Indiana







Before Fastener
After Fastener

# Astronautics

A PUBLICATION OF THE AMERICAN ROCKET SOCIETY, INC.

February 1959 volume 4 number 2



## EDITORIAL



## FEATURES



## MAN IN SPACE



## NEWS



## DEPARTMENTS



Print run this issue: 20,163

ASTRONAUTICS is published monthly by the American Rocket Society, Inc., and the American Interplanetary Society at 20th & Northampton Sts., Easton, Pa., U.S.A. Editorial offices: 500 Fifth Ave., New York 36, N. Y. Price $9.00 a year; $9.50 for foreign subscriptions; single copies $1.50. Second-class mail privileges authorized at Easton, Pa.  Notice of change of address should be sent to Secretary, ARS, at least 30 days prior to publication. Opinions expressed herein are the authors' and do not necessarily reflect those of the Editors or of the Society.

# Astro notes

### MAN IN SPACE

• AF is showing interest in a manned orbital bomber, capable of remaining in orbit 30 days while carrying a five- or six-man crew. Still in the planning stages, the project is likely to get a high-priority rating.

• Award of space capsule by NASA to McDonnell Aircraft Corp., "dark horse" among 12 competing bidders, came as surprise to many industry observers. McDonnell research group had quietly been working on the project for some time.

• A special Rand Corp. report prepared for the House Space Committee indicates the U.S.S.R. can be expected to add to its other astronautical laurels by becoming the first nation to send a man into space. The report notes that, in view of Russia's extensive space medicine studies, it is reasonable to assume that announcement of the "successful" return of a human passenger from a Soviet rocket flight can be expected in the not-too-distant future.

• In contrast, Soviet Academy of Sciences President Alexander Nesmeyanov said Russia will launch "a number" of satellites before attempts are made to put a man in orbit. Other immediate goals of the Soviet program, he added, are the launching of wholly or partially recoverable satellites and satellites with an almost unlimited life. The Soviet scientist's statement contradicts widely published reports that the U.S.S.R. had not launched any satellites for almost an eight-month period after Sputnik III because of the push for a manned satellite.

### SATELLITES

• AF has announced it is working on new techniques for nose-cone recovery, including recovery by use of aircraft. The techniques will be used in later shots in the Discoverer program, under which satellites will be launched into polar orbits.

• Russians have finally conceded the existence of an electronic satellite-tracking network, with ground stations equipped with both radio and optical instrumentation. Location of the links in the chain were not announced. Until now, the Russians have discussed only amateur tracking efforts.

### MISSILES

• Martin's Titan ICBM, under pressure from the Budget Bureau, survived the budgetary review, AF arguing successfully that Titan is a logical successor to Atlas because of its greater performance capability. Range estimates of 9000 n. mi. have been quoted for the weapon. On its first scheduled flight test at Cape Canaveral in December, Titan's first-stage engines cut out a few seconds after firing and the missile did not leave the pad.

• Polaris submarine program also won an Administration nod when the green light was given for the Navy to negotiate with General Dynamics for building lead vessel in a new class of missile subs, larger and heavier than the 5600-ton Polaris submarines already under construction and incorporating improvements based on experiences with existing nuclear subs.

• Army's Sergeant surface-to-surface tactical missile has entered the developmental hardware stage with announcement of $22 million contract to Sperry Rand.

• Low-cost, lightweight, reinforced plastic rockets and launchers may shortly be made available to NATO countries as U.S. long-term study program on plastic weapons appears about ready to produce.

**RESEARCH**

• Appointment of Herbert York, former ARPA chief scientist, to the post of DOD Director of Defense and Research Engineering, was hailed by astronautical engineers and scientists. Young (37), able and with an excellent background in the field, he will devote his major efforts to centralization of the Pentagon's sprawling R&D effort.

**EDUCATION**

• The ARS Maryland Section–Univ. of Maryland Space Education Institute gets under way March 2, winding up May 18. Nine lectures are scheduled, with Addison Rothrock of NASA, ARS President John P. Stapp, and Martin Summerfield among the lecturers.

• Brooklyn Poly has added a course in Astronautical Control and Guidance to its graduate curriculum leading to an M.S. degree in astronautics.

• MIT's Aeronautical Engineering Dept. is becoming a Dept. of Aeronautics and Astronautics, with a much broader program offered in space technology. The expanded department will be headed by Charles Draper.

**SPACE AGENCIES**

• NASA chief Keith Glennan laid it on the line the day Lunik passed the moon on its way into a solar orbit. Dr. Glennan said the U.S. has no long-range astronautical program, and that the first NASA task would be to develop such a program, covering both military and civilian projects.

• Despite published reports to the contrary, there is no danger that ARPA will pass out of the space picture next month. Rear Adm. John E. Clark, ARPA deputy director, notes that the agency was never intended to have a limited life, and that the frequently mentioned one-year limitation applied entirely to civilian space projects. These were turned over to NASA Oct. 1, leaving ARPA free to do the military work for which it was actually established (see page 44).

• NASA has set up a five-man Inventions and Contributions Board to evaluate scientific contributions to aeronautical and astronautical technology. Reporting to the NASA chief, the Board will recommend action which would reward inventors or contributors, or waive the government's title to inventions made in work performed under NASA contracts.

**IGY**

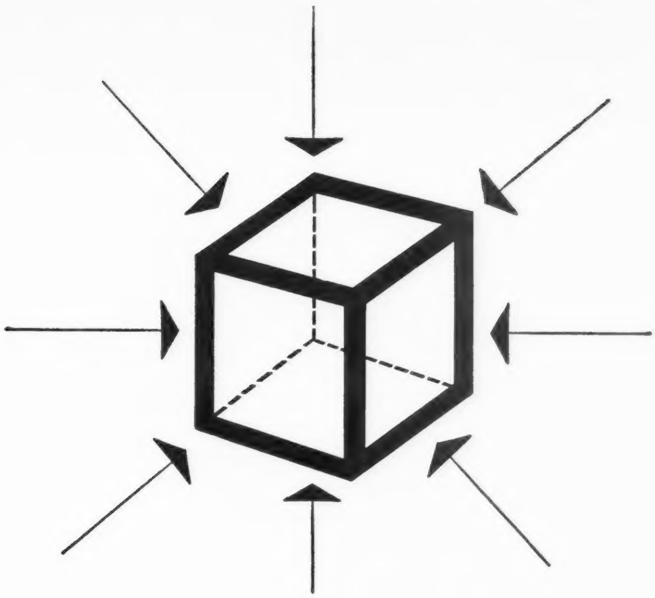
• NASA Basic Sciences Chief Homer E. Newell says it may take years before IGY data are carefully analyzed and complete reports issued. Executive vice-chairman of the USNC-IGY Technical Panel on Rocketry, Dr. Newell expresses the hope that there will be as much interest in IGY findings then as there is now. IGY ended Dec. 31, although a number of projects are being continued on an informal basis.

**ANTI-MISSILE DEFENSE**

• ARPA is studying an acoustical method for detection of re-entry warheads, based on the fact that a warhead crashing into the atmosphere produces extremely high-frequency sound waves. Studies have shown that initial impact of a re-entry body, as well as the echo traveling around the earth in the opposite direction, can be detected if suitable equipment is employed.

**INDUSTRY**

• Another missile-space team has been formed, this time by three Long Island N.Y., aircraft companies: Grumman, Republic Aviation, and Fairchild Engine & Airplane Corp. have announced their intention of joining forces "whenever advisable" on such projects, and already have begun work on some joint efforts.



## YOU MAY BE JUST THE MAN TO HELP BURROUGHS SQUEEZE A MILLION TRANSISTORS INTO A CUBIC INCH

**OR EXPLORE FIELDS LIKE THESE:**

- Statistical approaches to physiological processes
- Electro-chemical phenomena
- Radiation effects
- Plasma physics
- Magneto hydro-dynamics
- Electro-luminescence
- Cryogenics
- Superconductivity
- Semi-conductors
- And a lot of others

Right now—today at Burroughs: plenty of room for exceptional engineers to help create the *successors* to Burroughs' big line of advanced electronic and electro-mechanical data processing equipment. Equipment that ranges from giant electronic computer systems to automatic accounting machines and more.

We need men who can help us put the functional equivalent of a million transistors into a cubic inch of material. Or men who can help us produce equally advanced results in fields like those mentioned at the left.

Men who can thrive on working without strait jackets.

Men who can get the most out of our heavily budgeted research facilities.

Men who can welcome the security of our *cohesive* research programs. How cohesive? Because their common aim is to improve information processing for both commercial and military use. How do the programs offer security? Because their cohesiveness allows you to shift readily from one to another without learning a new technology.

We want men whose creativity will help us double our $300 million yearly sales rate fast—and then redouble it even faster.

Men who are frankly interested in increased responsibility. In swift promotion in careers that offer a wide choice of location. And, yes, in money.

Are you as outstanding as these opportunities? Then outline your education and experience as briefly or fully as you wish, name the field you'd like to help us explore, and get that information to A. L. Suzio, Administrator, Corporate Placement Services, Dept. 104, Burroughs Corporation, Detroit 32, Mich.

Burroughs

**Burroughs Corporation**

"NEW DIMENSIONS / IN ELECTRONICS AND DATA PROCESSING SYSTEMS"

# For the record

The month's news in review

*Dec.* 2—CAB proposes amateur rocketry curbs in its amendments to civil air regulations.

*Dec.* 3—President Eisenhower allows Army to hold on to its Ballistic Missile Agency, but transfers Jet Propulsion Laboratory to NASA.

—DOD announces long-range, one-a-month satellite launching program aimed at placing animals, then man, in space, with payloads becoming progressively larger.

*Dec.* 5—Navy discloses plans for new AA guided missile called Eagle.

—Three chemical engineers at Callery Chemical Co. are killed, two injured critically, when "homemade" rocket blows up.

*Dec.* 6—Army's first lunar vehicle, Pioneer III, fails to achieve escape velocity, but gets 66,000 miles into space and finds two radiation bands girdling the earth, one 1400–3400 mi from earth's surface and the other 8000–12,000 mi.

—President directs NSF to form Science Information Service to coordinate government and private scientific information.

*Dec.* 7—Russia says Sputnik III carrier rocket disintegrated Dec. 3.

*Dec. 10*—Khruschchev tells Sen. Humphrey (D., Minn.) that Russia has 8700-mile ICBM capable of delivering an atomic warhead.

—Navy successfully fires Regulus II from surface ship for first time.

—President Eisenhower says there is "absolutely no reliable evidence" that Russians have flown a nuclear-powered plane.

*Dec. 12*—AF cancels Fairchild Goose.

*Dec. 13*—Army sends monkey 300 miles into space in Jupiter missile but fails to recover nose cone.

—State Dept. resumes program—discontinued by President Eisenhower in 1956—of appointing science attaches to serve our embassies abroad.

*Dec. 16*—Pacific Missile Range opens with successful AF Thor firing.

*Dec. 17*—Administration orders sharp cut in funds for atom plane development.

—NASA lets order to Rocketdyne to develop and build a 1.5-million-lb thrust rocket engine capable of launching vehicles weighing several tons.

—NASA chief T. Keith Glennan discloses man-in-space program has been given code name of Project Mercury.

—Navy cancels Regulus program.

*Dec. 18*—AF orbits 4-ton Atlas Score, with communications relay system.

*Dec. 19*—Orbiting Atlas transmits President's taped Christmas message back to earth.

*Dec. 20*—Two-way radio messages are sent between U.S. and Atlas satellite.

—First AF Titan launching fails on pad due to malfunction.

*Dec. 21*—House Space Committee report urges international regulation of space launchings, warning that unannounced satellite might be mistaken for attacking missile.

*Dec. 22*—Soviet Union increases science budget for 1959.

*Dec. 23*—Administration says it intends to continue launching rockets without prior warning.

—AF Atlas is successfully test-fired 4000 miles.

*Dec. 24*—President names ARPA chief scientist Herbert F. York to direct all Pentagon research and engineering.

—Pentagon says Atlas ICBM will be combat ready in 1959, with first operational squadron to be based at Vandenberg AFB.

*Dec. 27*—James R. Killian Jr., special assistant to the President for science and technology, is named head of the new Federal Council for Science and Technology, aimed at improving planning and management of Government research programs.

—NASA Deputy Administrator Hugh L. Dryden says U.S. long-range plans call for launching satellites weighing 40 tons or more.

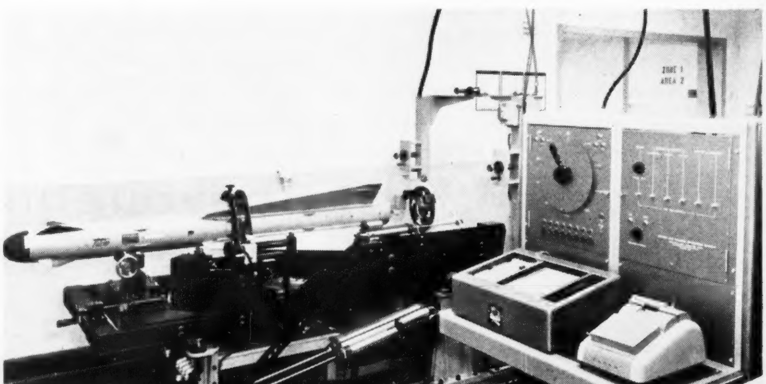
*Dec. 30*—AF Thor blows up shortly after launching.

—Navy Polaris is destroyed after takeoff.

*Dec. 31*—IGY officially ends.

## Measures Falcon's CG Alignment Electronically

**This weight and balancing system, designed and built for Hughes Aircraft by Baldwin-Lima-Hamilton, automatically measures CG, weight and thrust alignment of Falcon in five minutes.**




ELECTRO SNAP
Creators of over 6,000 Precision Switches and Controls
presents . . .
A new panel concept that promises to revolutionize monitoring or control of Missiles and Rockets
the astromatic panel concept
"THE MOST EFFICIENT LINK BETWEEN MIND AND MACHINES"
Consider These Obvious Advantages in Your Designing
★ OFFERS INSTANT VISUAL CONTROL WITH EXTREME ACCURACY
★ REDUCES HUMAN ERROR TO AN IMPROBABILITY
★ PROVIDES SIMPLIFICATION OF THE MOST COMPLEX OPERATION
★ ALLOWS REMARKABLE CONSERVATION OF VITAL SPACE
★ WITHSTANDS EXTREME LIMITS OF TESTING SPECIFICATIONS
★ APPLICATION POSSIBILITIES AS UNLIMITED AS THE IMAGINATION
PROPELLANTS SUBSYSTEMS
NITRIC-ACID SUBSYSTEM
HYDRAZINE SUBSYSTEM
$H_2O_2$ SYSTEM
COUNTDOWN
MINUTES
SECONDS
38
17
WARHEAD
GUIDANCE
ENGINES
Study the following specifications with your project in mind . . . .
ASTROMATIC DIVISION
Electrosnap Corporation
4218 West Lake Street, Chicago 24, Illinois

# the astromatic panel concept by ELECTROSNAP


**Ready now for tomorrow's higher control requirements**

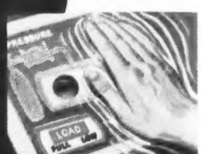
## HUMAN FACTOR ENGINEERED for highest efficiency with extreme accuracy

This new concept in panel techniques combines the latest advances in scientific, technological and psychological achievements to insure the highest possible degree of efficiency and accuracy in control or monitoring of equipment.

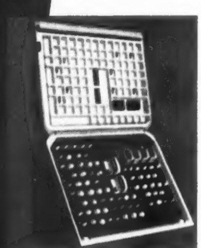
## PRECISION ENGINEERED

**... Meets or exceeds most exacting specifications**

SHOCK AND ABUSE TOLERANT ... Laminated Fiberglas panel resists chipping, shattering, crazing. Coefficient of expansion identical to aluminum sub-assemblies eliminates buckling under stress or extreme cold or heat conditions.




LASTING LEGIBILITY ... Exclusive process imbues color into Fiberglas ... resists wear-off of legend and diagramming. Vivid colors actually photoprinted—will not chip or scratch off. Meets all requirements of MIL-P-7788 for Aircraft Cockpit Panel.

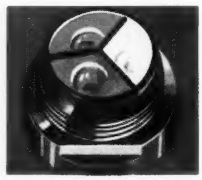


QUICK LAMP REPLACEMENT...Front panel hinged for quick access to components below, permitting 10-second bulb change if necessary.

EASY TO ALTER ... During prototyping legend and schematic diagramming can be easily changed to visualize any new findings. Components under panel may be relocated.

VERSATILITY OF DESIGN ... The module concept of construction makes the Astromatic panel technique extremely versatile. WHATEVER ACTION YOU DESIRE TO VISUALIZE, ASTROMATIC CAN SUBMIT A PANEL DESIGN TO SURPASS YOUR EXPECTATIONS.

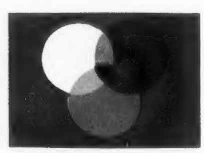

100% FLUSH PANEL ... Eliminates protruding hardware ... unless specified by human engineering requirements. Switching functions may be recessed, flush, or over-flush.



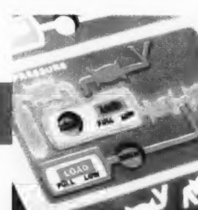
TRI-COLOR LIGHTS ... Each light module contains 3 separate bulbs and circuits to permit triple indications such as GO, NO-GO and CAUTION signalling.

CONCENTRATED GROUPING OF CONTROLS...Multiple function of TRI-LITE controls permits high component density, saving from two to four times space required by ordinary panel. Permits instant visual recognition and action by operator, minimizing time-loss found in larger panels.

VERSATILE SWITCHING ... The switching and indicating techniques are specifically designed for maximum compatibility with this advanced panel. Momentary, positive feel and alternate action switching is available.



LIMITLESS COLOR COMBINATIONS ... The unique combination of TRILITES plus multi-color photo printing of panel allows unlimited color guidance, distinctly identifiable even by color blind.




SCHEMATIC DIAGRAMMING ... Photo color printing of panel surface permits visual schematic diagramming. Increases speed and efficiency of operators and recognition of system indications. Reduces indoctrination period for operator training. Eliminates the written word.

MAIL COUPON BELOW FOR ADDITIONAL TECHNICAL INFORMATION ... OR PHONE ROBERT PROVART, TECHNICAL DIRECTOR COLLECT, VAN BUREN 6-3100

**Astromatic Division, Electrosnap Corporation**
4218 W. Lake Street, Chicago 24, Illinois

**Gentlemen:** ☐ **Have your Design Engineer call for an appointment.**
☐ **Please count me in on any Symposium held in my area.**

Name________________ Title________________

Company________________

Address________________

City________________ Zone____ State________



## ASTROMATIC DIVISION

**Electrosnap Corporation**
4218 W. Lake Street, Chicago 24, Illinois
VAn Buren 6-3100, TWX CG-1400

# International scene

BY ANDREW G. HALEY

Several new astronautical societies have appeared on the world scene in recent months, each able to boast of very distinguished membership, including famous names in the fields of the natural and social sciences.

Close to home are two new societies in Canada—the Astronautical Society of Canada and the Canadian Astronautical Society. Others, either already existing or proposed, are the Bulgarian Astronautical Society, Astronautical Society of the Republic of China, Hellenic Astronautical Society, Israel Astronautical Society, Japanese Rocket Society, and astronautical societies in Czechoslovakia, Hungary, India, Iran, Ireland, Portugal, and Turkey.

° ° °

The *Bulgarian Astronautical Society* was formed within the Bulgarian Academy of Science, with four men serving as the organizers. Nikola Bonev is a corresponding member of the Bulgarian Academy of Science, director of the Astronautic Observatory in Bulgaria, and president of the Bulgarian society. A well-known scientist, he is the author of a great number of valuable studies of the moon surface and a long-term member of the international committee to study the moon. Mag. ing. Georgy Asparuhov is general secretary of the society and chief engineer of the Bulgarian Civil Air Transport. A graduate of the Univ. of Berlin, he is the author of many popular scientific articles and monographs on the development of rocket techniques. Mag. jur. Todor Gabrovski, legal adviser of the Bulgarian Civil Aviation Authority and one of the most prominent organizers of the society, is the author of one of the first publications (1956) concerning the juridical problems of outer space, and has also written a great many scientific works. Maj. Gen. Kiril Kirilov, general manager of the Bulgarian Civil Air Transport, was also an active organizer of the BAF and rendered great assistance during its formative period.

The Bulgarian society presented full credentials at the Ninth IAF Congress and was seated. The Congress delegation was headed by Prof. Bonev.

° ° °

The *Astronautical Society of Canada* was organized in January 1958, as the Canadian Astronautical Society. The organizing committee was headed by Eugene Pépin, director of the Institute of International Air Law, McGill Univ.; the first organizational meeting was held at McGill Univ. in Montreal on April 18, 1958. The meeting was presided over by David L. Thomson, vice-principal of the university and Dean of the Faculty of Graduate Studies and Research. Membership includes numerous officials of the International Civil Aviation Organization (ICAO), faculty members of universities located not only in Montreal but throughout Canada, practicing physicists, engineers, doctors, lawyers, and business leaders in the field of aeronautics.

President of the society is Gordon R. McGregor, president of Trans-Canada Air Lines, and a pioneer aeronautical expert. Dr. Thomson is vice-president. The secretary is H. T. P. Binet, distinguished lawyer and former official of the International Labor Office, Geneva, and the treasurer is Ronald A. Javitch.

The society holds regular meetings which are very well attended. One of these meetings included a much quoted lecture by Prof. E. R. Pounder on the scientific use of earth satellites, while another was highlighted by a lecture on space law delivered by Dr. Pépin. The society is in the process of publishing a monthly periodical to be called "The Bulletin."

° ° °

There exists in Canada the remarkable situation of a great nation which was long without any astronautical society and suddenly finds itself with two first-class organizations. At about the same time the McGill society was organized, and perhaps a little earlier, there was organized in the Toronto area under the leadership of A. E. Maine and others the *Canadian Astronautical Society*. The original nucleus was composed of physicists and technicians at the De Havilland Aircraft of Canada Guided Missile Div. at Downsview, Ontario.

Membership of the society is by no means confined to the De Havilland organization, but embraces distinguished natural and social scientists and workers from many universities throughout Canada, and the commercial, cultural, and educational strata of the nation. The officers and directors are: President, Phillip Lapp, senior project engineer, De Havilland Guided Missile Div.; secretary, A. E. Maine, chief electronic development engineer, De Havilland Guided Missile Div.; and treasurer, R. R. Taylor.

Two experimental projects are being conducted by the society. The first is the Charm (Canadian High Altitude Research Missiles) Project. The society has built a complete rocket system and expects to be firing rockets to 120,000 ft by the end of next year. Atmospheric data will be telemetered back to the ground. The society has built all the hardware except the launcher, and is presently developing radioburning solid grain rocket motors. The second is the Champ (Canadian Lunar Antenna Moon Probe) Project. The society is building a 150-ft diam parabaloid to receive radio transmissions from the vicinity of the moon. This is in the design stage, but construction work has already commenced. The use of a 100-ft mast made of fiber glass inside the parabaloid is a radical development.

The society distributes a bi-monthly news letter as well as technical reports. The first proceedings of the society are just being printed. An interesting highlight last October was Canada's first astronautical exhibition held in Toronto. A large amount of equipment was built by the society, with the U.S. Army also furnishing interesting satellite exhibits.

During the year, numerous speakers appeared on the society's programs, including Gerry Bull, of the Aeroballistics Div. of CARDE, who spoke on aeroballistic techniques in astronautics, and N. G. Patterson, of the Institute of Aerophysics, Univ. of Toronto, who spoke on plasma dynamics.

Dr. Pépin and Maine both attended the Ninth IAF Congress, with the question of seating the societies postponed for a year because of their expressed desire to merge the two groups into one organization.

° ° °

The *Astronautical Society of the Republic of China* was formed in July 1958, with an initial membership of 56, and was admitted to membership in the IAF at the Ninth Congress. Lynn Chu, director of the Air Technical Bureau, Taichung, Taiwan, is chairman of the society, with Chih-Bing Ling, director of the Aeronautical Research Laboratory in Taiwan, representing the society at the IAF Congress. Membership of the society is from the various establishments of the Chinese Ministry of Education, research laboratories, and other institutions, including the Weather Bureau, industrial establishments, and several universities.

° ° °

The *Hellenic Astronautical Society*

(CONTINUED ON PAGE 78)

# Capital wire

News highlights from Washington

## SATELLITES

• Crowing over U.S. "talking satellite" came to an abrupt halt with successful launch of Soviet "Lunik." Spectacular Russian achievement terminated discussion of technical magnitude of Atlas-Score shot and brought realization U.S. still trails in space race. Earlier, Pentagon officials had noted that Atlas, with upper stages added, could match or exceed Soviet payloads. While this may be true, the 800-lb instrument package the Russians put in space is more than an order of magnitude greater than payloads in unsuccessful U.S. attempts to date.

• Oddly enough, Lunik launching was announced only an hour after House Space Committee had urged the White House to order two additional U.S. moon shots as early as possible. News of the feat produced violent reaction from many Congressmen, foreshadowing bitter fight over U.S. space program between one group in favor of all-out effort to match Soviet accomplishments and another which feels we should go ahead with carefully-planned, well-coordinated program regardless of Russian "stunts." Whichever group wins out, the likely result is a big boost in spending for space research.

• In addition to the announced Score communications relay experiment which received, recorded, and rebroadcast the President's Christmas message and other messages, the Atlas satellite also carried into orbit some secret military experiments. The nature of the experiments was not disclosed, but officials said 100 per cent of the signal of one beacon was modulated with telemetry and 20 per cent of the other.

## MAN IN SPACE

• A major potential roadblock to Project Mercury, the U.S. program to put man in space, has been cleared away by James A. Van Allen. Instead of one huge radiation belt surrounding the earth, there are two belts or shells of moderate size. They consist of energetic protons or electrons (most likely the latter) trapped in the earth's magnetic field. The lower shell is centered at an altitude of 2400 miles; the upper one at 10,000 miles. Maximum intensity within the belts is about 5 to 10 roentgen, assuming the particles are electrons. Between them is an area comparatively free of radiation, with the intensity at 6000 miles believed to be only 0.3 r per hr. This means manned vehicles will not necessarily be confined to extremely low orbits, and, even more important, that a quick dash through the belts would result in only mild radiation doses during interplanetary jaunts. Dr. Van Allen's new findings were achieved with two tiny radiation counters aboard the Army's Pioneer III lunar probe.

• Negotiations got under way last month between NASA and Rocketdyne for development of a single-chamber rocket engine of one million pounds thrust. The huge engine is expected to cost more than $200 million and require four to six years of effort. This suggests something of Project Mercury's long-range timetable. Since existing ballistic missile boosters will probably be limited to orbiting small manned capsules, the new engine will have the job of supporting construction of a space station, as well as manned interplanetary attempts.

• With an eye to the future, Lockheed recently completed a $200,000 study of the requirements for placing a 10-man space station in a 500-mile-altitude orbit. The station would be a 94-ft wheel shaped satellite weighing 400 tons. Components would be lifted separately into orbit by three-stage rockets 182 ft high. Assembly would be accomplished by three-man "astro-tugs."

• AF is studying the feasibility of a follow-on model of the X-15 which would be capable of 6000 mph.

## MISSILES

• Defense economies exacted a high toll in missile casualties as the fiscal 1960 military budget was put in shape for presentation to Congress. Chance Vought's Regulus II supersonic air-breathing missile was dropped, Fairchild's long-range Goose decoy cancelled, and Bell's air-to-ground Rascal discontinued after the expenditure of $374 million. Cuts followed a new Pentagon policy of emphasizing ballistic missiles and reducing support for air-breathers. Major exceptions: North American's air-launched Hound Dog, now in development, and Northrop's intercontinental Snark, which received a $50 million order to continue production through December 1960.

• Chance Vought is pushing a new idea for a nuclear-powered air-breathing missile. Presumably based on AF and AEC studies of the Pluto atomic ramjet, the missile would be capable of prolonged airborne patrols.

• Promising initial test firings of air-launched ballistic missiles may provide existing manned bombers with a new lease on life. Under a program called "Bold Orion" (WS-199), both Lockheed and Martin, together with supporting contractors, have built and fired prototype ballistic missiles at the Cape Canaveral range. A single-stage Lockheed missile was fired at 1100 mph from a Convair B-58; Martin launched a two-stage missile from a B-47.

## ICBM DEFENSE

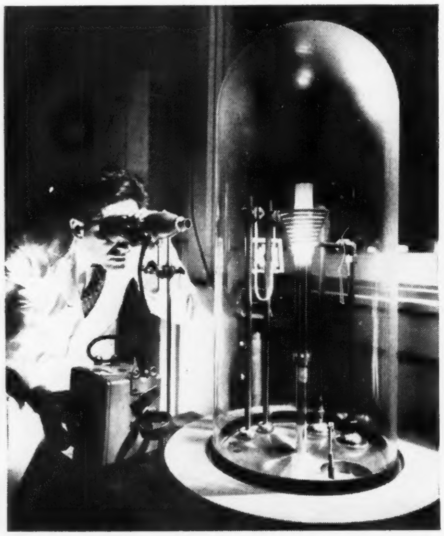
• The extreme difficulty of intercepting a re-entering ICBM warhead by "conventional" means, i.e., anti-missiles, has led to considerable emphasis on "blue sky" schemes for countering the threat. One idea proposes the use of a defensive screen of satellites capable of roasting enemy warheads with dense ion beams. Another utilizes the earth's geomagnetic trap, and involves the injection of a huge quantity of short-lived radioactive ions into the trap and their decay into neutrons which would pre-initiate a nuclear reaction in the fissionable trigger of the warhead.

## CAPABILITIES FOR DEFENSE

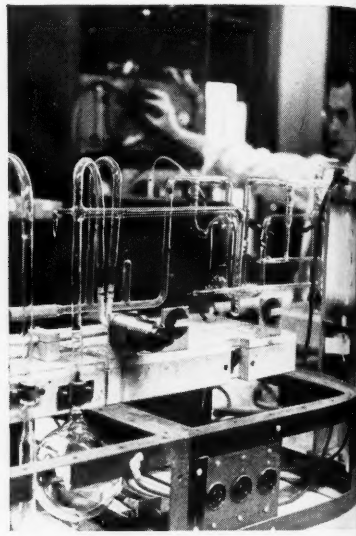
# Westinghouse is spending $185 million for research and development in 1959

### HERE ARE SOME CURRENT PROJECTS...

**HIGH TEMPERATURE ELECTRICAL INSULATION.** Effective for long periods at 500° C—eventual applications to 1000° C now contemplated. Demonstration motor shown above is running red hot. *Aircraft Equipment Department, Materials Engineering Departments, and Research Laboratories*



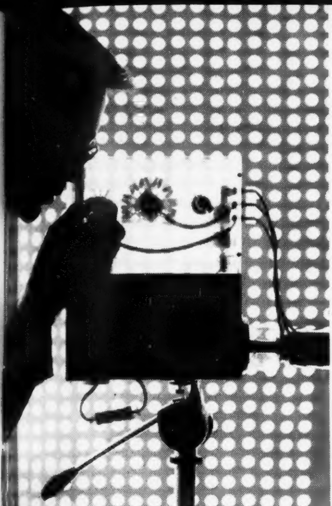
**SPECIAL METALS.** Westinghouse spearheads research in refractory alloys with one of the country's largest programs in special metals. Westinghouse is nation's principal supplier of a number of special defense-application metals. *Materials Manufacturing Department, Aviation Gas Turbine Division and Lamp Division*



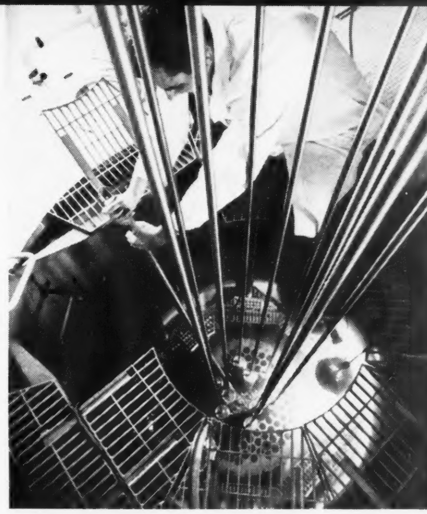
**HIGH-VACUUM RESEARCH.** Extensive high-vac research conducted since 1947. Current area investigation include electrical and chemical p ing in ultra high-vacuum range and compo development for large high speed pumping sys Results being applied in advanced electronic de development. *Air Arm Division and Rese Laboratories*

**UNDERWATER SONICS.** Current Westinghouse projects being conducted in laboratories and at sea are investigating various types of "scatterers" and their effect on the underwater transmission of sound. Also under development: acoustical torpedo controls and an acoustical mine identification system. *Ordnance Department and Research Laboratories*

**NON-ROTATING 360° RADAR ANTENNA.** Only the feed point moves. Prin involved will permit economical construction of very large high gain sca antennas. Application of inflation techniques will permit lighter-weight long-ra air-transportable radar. Working models already built and evaluated. *Electr Division and Research Laboratories*

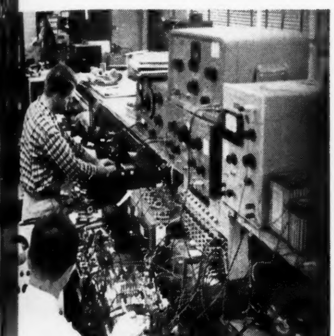


**HT AMPLIFICATION,** through electron bom- dment induced conductivity. Extremely sen- e. Principle especially useful for satellite nnaissance devices. Efficient working mod- have been developed. ***Electronic Tube ision, Astronautics Institute and Research oratories***

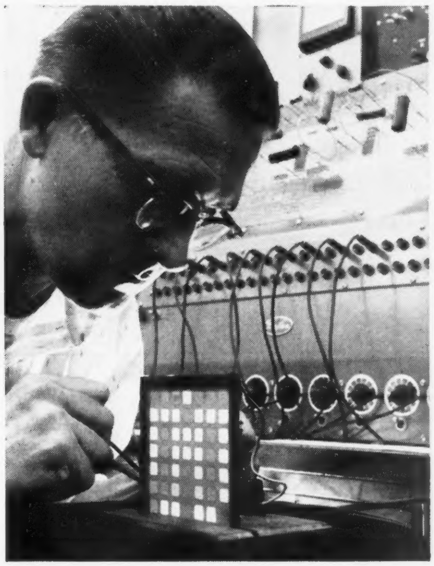


**NUCLEAR RESEARCH.** At the Westinghouse Testing Reactor, engineers are preparing high intensity radiation tests on a wide range of materials to determine their structural, chemical, and nuclear stability. This is a necessary prelude to using these materials in certain atomic power applications now under development. ***Atomic Power Department***

**INFRARED** research projects include: *thermal imaging* — working models in advanced development; *ultrasensitive doped crystal detectors* — advanced test models; *photo-electric magnetic detection* — working model. ***Air Arm Division, Semi-Conductor Department, Materials Engineering Departments, and Research Laboratories***

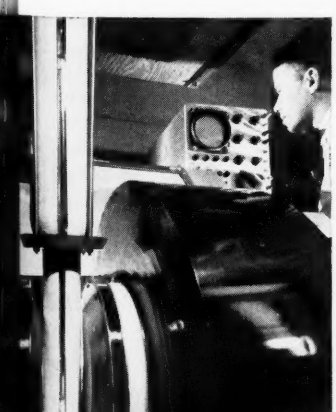


**LSE-DOPPLER RADAR** is in advanced devel- ent in three major areas of application at tinghouse. Research is continuing to open new potentials. Westinghouse is the nowledged leader in this field. ***Air Arm sion***



**NEW DATA DISPLAY DEVICES.** Electroluminescent cells, individually controlled, form flat picture. Model has oversize cells for demonstration; latest techniques produce cells only 1/16" across. Similar tote board display, capable of high-speed read-out of digital inputs, in production. Both devices can be erased instantly or retained and studied for long periods. ***Electronics Division, Rayescent Lamp Department and Research Laboratories***

**THERMOELECTRICITY.** Westinghouse recently developed the first efficient material to produce electricity directly from heat at high temperatures (1100° C). In addition, other thermoelectric material under development can be used for cooling purposes, including very light-weight applications. Forty Westinghouse scientists now on this project. ***Materials Engineering Department and Research Laboratories***



**LOW-NOISE MICROWAVE AMPLIFICATION.** Westinghouse scientists have developed vari- low-noise solid-state amplifying devices, MASER and non-linear reactance types. gress in recent years was speeded by prior rs of research in low-temperature and solid- physics. ***Air Arm Division and Research oratories***

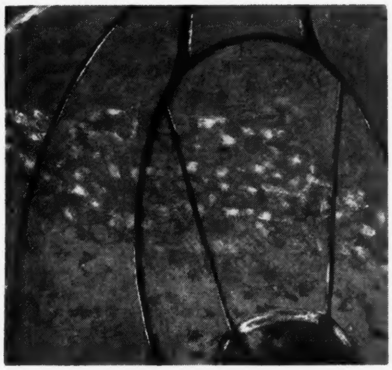
For information on these and other research projects, write to Mr. E. W. Locke, Director, Customer Relations, Westinghouse Defense Products Group, 1000 Connecticut Avenue, N.W., Washington 6, D. C.

# Westinghouse

**DEFENSE PRODUCTS**

**AIR ARM DIVISION**
**AVIATION GAS TURBINE DIVISION**
**ELECTRONICS DIVISION**
**AIRCRAFT EQUIPMENT DEPARTMENT**
**ORDNANCE DEPARTMENT**

**YOU CAN BE SURE... IF IT'S** Westinghouse



COVER: *"In Space"—an impression in oils by artist Erwin Wending of the view which will greet the first man in space.*

# Astronautics

FEBRUARY 1959

## The First Hundred Miles

On provecting toward castles framed against a far horizon, first the glittering spires are faintly seen, then the solid towers enlarge the approaching view, and finally the foundation walls, firmly embedded in the earth, are beheld as the base from which the whole was built. We thus progess from castles in the air to reality, which begins from the ground up.

From our present perspective, placing a manned artificial satellite into an elliptical orbit around the moon, and returning it safely to earth, seems closer to realization with every moon probe launching. Many space enthusiasts no longer regard this as extraordinary, and even advocate a direct moon landing instead. In the headlines, million-mile round trip excursions into space are just around the corner; in fact, man has not yet ascended the first hundred miles. For much the same reasons that there are no holiday cruises to the Antarctic, there is little prospect that expeditions to the moon will ever be other than scientific explorations.

The first hundred miles of the vertical frontier can be explored with thrust-lifted vehicles under the control of the crew, ascending, hovering, and descending with modulated power and reaction controls, at a cost of one-sixteenth the power required for attaining the same altitude with tangential orbital velocity.

By incremental extension beyond aeronautical technology into progressive astronautics, a spectrum of less-than-orbital-velocity flight programs can be worked out along with the development of vehicles to exploit the momentum-glide possibilities of the upper atmosphere. Here, 18 times the velocity attainable with the fastest jet airliner can be obtained at one-fourth the fuel cost. At more than 10,000 mph, astronautical transport service of less than two hours between any two astroports on earth is an attainable objective. Apodictically, this does not include transportation between town and astroterminal.

Unquestionably, the go-for-broke endeavor to conquer outer space is of prime importance, but the technological mastery of the first hundred miles above the earth has the attractiveness of a good investment.

**—Col. John P. Stapp (USAF-MC)**
President, American Rocket Society

# Open letter to the U.S.S.R.

## ARS President congratulates Russians on Lunik shot, invites them to present papers at ARS meeting, seeks additional information

ON JANUARY 2, the Russians accomplished what might be called Step Two in their carefully planned, well thought-out astronautical program by achieving what is referred to in Soviet terminology as the "second cosmic velocity" (escape velocity) of just over 11 km/sec (7 mps) with their "Lunik."

A few days later, Col. John P. Stapp, President of the American Rocket Society, sent the following letter to the President of the U.S.S.R. Academy of Sciences:

Dr. A. N. Nesmeyanov
President, U.S.S.R. Academy of Sciences
Moscow, Russia

Dear Dr. Nesmeyanov:

The American Rocket Society's 12,000 members congratulate their fellow scientists and engineers in the Soviet Union on the successful launching on January 2 of the Soviet lunar probe vehicle. Development of a propulsion system capable of propelling a vehicle to escape velocity; establishment in orbit of the first artificial solar satellite; and the transmission and reception of radio signals over much greater distances than have heretofore been attained, all mark major steps in the conquest of space.

We eagerly await announcement of the full details of the experiment, and cordially invite representatives of the Academy of Sciences to present scientific papers dealing with the Soviet lunar exploration and astronautical research programs at the American Rocket Society's 14th Annual Meeting in Washington, D. C., November 16–20, 1959. We would also undertake to transmit to American scientists and engineers in the field of rocketry and astronautics invitations to present similar papers at scientific meetings in the Soviet Union.

We would also be happy to make space available in Astronautics and the ARS Journal, the two American Rocket Society monthly publications, for scientific and technical papers dealing with these subjects.

Academy member A. A. Blagonravov, in a published statement following the launching of the lunar rocket, noted that, "in the Soviet Union, any cosmic experiment is first and foremost a scientific experiment." In view of this statement, and of the intense interest of astronautical engineers and scientists throughout the world in the Soviet lunar probe, we would very much appreciate it if you could answer a number of questions about the experiment.

These questions are:

1. Can you provide us with information as to the total thrust, number of stages, and propellants used?
2. How close was the final trajectory to the programmed trajectory? In other words, how accurate was the launching from the standpoint of timing, velocity cutoff, and trajectory angle?
3. What type of guidance was employed?
4. Can you supply accurate orbital data at this time?
5. What are the main elements in the system used to track the vehicle?
6. What have been the principal findings to date with respect to cosmic radiation, ultraviolet radiation, and temperatures and pressures in space?
7. What data have been received on the lunar magnetic field?
8. Was any attempt made to measure light reflection from the far side of the moon in the experiment?

We will be glad to provide space in Astronautics for your replies to the above questions, and sincerely hope that you can make the information available to us.

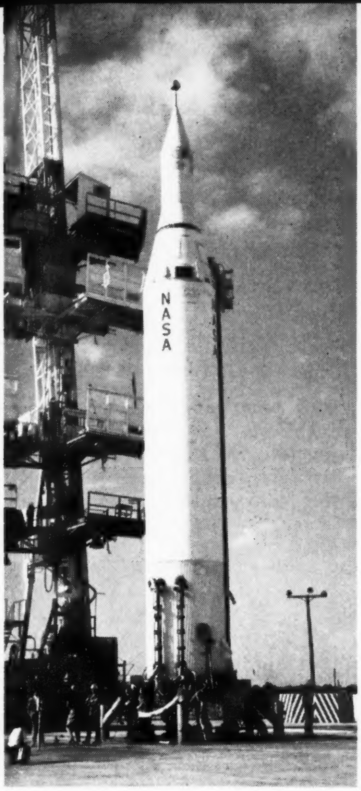
Cordially yours,

John P. Stapp, M.D., Ph.D.
President, American Rocket Society

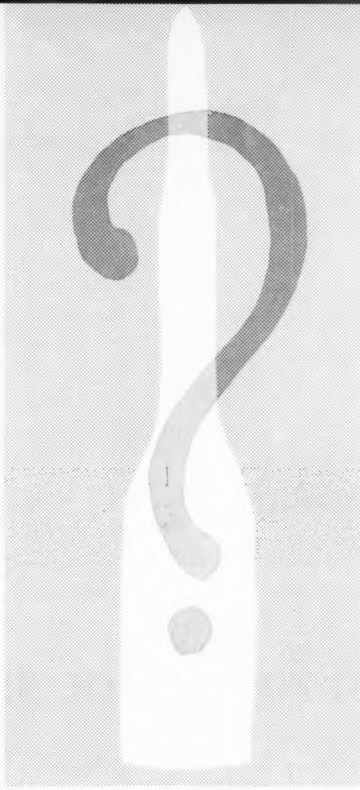
---

The Russians appear to be having every success with their equipment. On Jan. 3, Dr. Blagonravov, a noted Russian ballistician, stated that instruments and radio transmitters on Lunik were working normally and sending back a vast amount of data. A Moscow broadcast the same day reported that temperatures inside Lunik were between 50 and 59 F, a good temperature range for normal functioning of its instruments.

Procedures for dissemination of additional information from Lunik, after data have been reduced, have not as yet been announced by the Russians. While the Soviet Union has already indicated willingness to continue international cooperation in scientific experimentation beyond the official end of the IGY period, which ended last Dec. 31, it is not known whether details about the lunar probe




**Juno II**



**Lunik Launcher**

**Thor-Able**

## MOON PROBE VEHICLES

will be made public, despite Dr. Blagonravov's statement.

Launching of Lunik, coming on the heels of the Atlas Score shot, the most successful U.S. effort to date, at least from the standpoint of payload, in the space race, was another blow at American astronautical prestige. Size of the Soviet payload—almost 800 lb—provided another indication of Russian propulsion capability, while the accuracy of the shot —Lunik came within some 4600 miles of the moon— points to excellent guidance characteristics.

### Another Propaganda Triumph

Reaching escape velocity and establishing the first artificial satellite of the sun are, of course, remarkable scientific and technical accomplishments. However, the excellent Soviet security system also assured another propaganda triumph as well. No mention was made as to whether the vehicle was programmed to hit the moon, orbit the moon, or achieve the close miss which actually resulted. Also, to the public, the successful Lunik launch means the Russians apparently succeeded in their very first try (regarded as extremely doubtful by many U.S. astronautical experts). —I. H. and J. N.

### Russian Data on Lunik I

**Schedule**

| | |
|---|---|
| Launching | Jan. 2, 1959 |
| Closest approach to moon (about 4600 miles) | Jan. 4, 1959 |
| Perihelion at 91½ million miles | Jan. 14, 1959 |
| Aphelion at 123¼ million miles | Sept. 1959 |

**Payload weight**

| | |
|---|---|
| Total | 3245.2 lb |
| Instruments | 796.5 lb |

**Velocity**

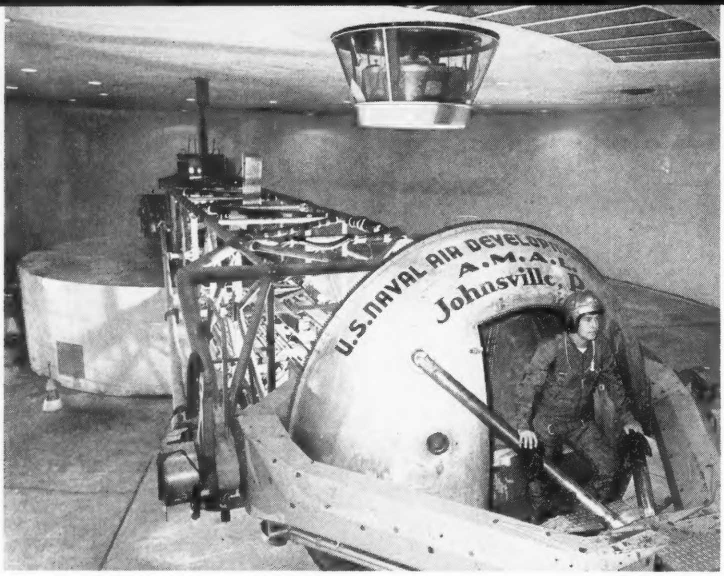
| | |
|---|---|
| Earth departure | about 7 mps |
| 176,540 miles from Earth | 5589 mph |

**Communications equipment:**

Three transmitters—one emitting on two low frequencies (19.997 and 19.995 mc) for tracking of Lunik; one emitting telegraphic messages at 19.993 mc to convey instrument readings; and one emitting on a high frequency (183.6 mc) for both tracking and transmission of instrument readings.

**Experiments:**

Sodium-vapor discharge for camera tracking; measurements of magnetic field of moon, intensity of cosmic radiation outside Earth's magnetic field, photon density in cosmic radiation, distribution of heavy nuclei (such as iron) in cosmic radiation, corpuscular solar radiation, gaseous components of space, radioactivity of moon, meteoric particles, and inside and outside temperatures of the probe.




This unique 50-ft radius centrifuge is the most versatile machine existing for testing human acceleration tolerance, prime factor in setting the performance of manned space craft.

# Preparing man for space flight

## Acceleration studies with the Navy's huge, unique centrifuge at Johnsville probe man's resources as a space pilot, and prepare him for fateful days to come

Clark

Hardy

Carl C. Clark is head of AMAL's Biophysics Div. He received a B.S. degree in physics from Worcester Polytechnic Institute in 1944 and a doctorate in zoology from Columbia Univ. in 1950. He assumed his present position in 1954, after serving as a research associate in physiology at Cornell Univ. Medical College and as assistant professor of zoology at the Univ. of Illinois. Dr. Clark is also an associate in physiology at the Univ. of Pennsylvania School of Medicine.

James D. Hardy is research director of AMAL. After receiving a doctorate in physics and mathematics from Johns Hopkins in 1930, he was a National Research Council Fellow in physics at the Univ. of Michigan until 1932, when he was appointed Research Fellow at the Russell Sage Institute of Pathology in New York City. During WW II, he served on mine sweepers in the European theater, and for this duty was decorated with the Purple Heart and the Legion of Merit. Following the war, he was a professor of physiology at Cornell Univ. Medical College until 1953, when he was appointed professor of physiology at the Univ. of Pennsylvania and director of AMAL. Dr. Hardy's chief studies have concerned body temperature regulation and physiological effects of acceleration.

*By Carl C. Clark and James D. Hardy*

AVIATION MEDICAL ACCELERATION LABORATORY, U.S. NAVAL AIR DEVELOPMENT CENTER, JOHNSVILLE, PA.

OUR TASK of preparing man for space flight is, first, to insure that he has adequate physiological and psychological ranges, including the desired performance capabilities, and, second, to provide a local environment which keeps him within these ranges.

Selection of a seemingly suitable man is the first step. Selection will be based on an examination of the candidate's physiological and psychological tolerance ranges. This involves measuring the candidate's bodily and mental responses in altered and generally stressful environments. We emphasize the importance of performance capabilities. The space pioneer presumably will not only be healthy but also have mature and experienced responses, probably evidenced by technical and graduate degrees. The popular conception of the space pilot as a vigorous 18-year-old athlete may miss this point.

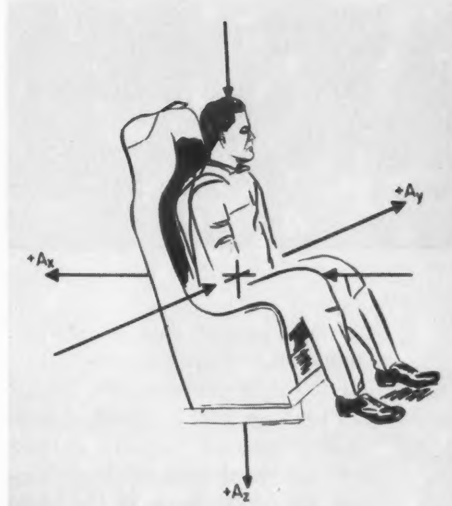
Once the pilot is selected, we may modify him by training, particularly with regard to his performance ranges. There are, in addition, procedures not yet well worked out which may alter our pilot physiologically and biochemically to increase his tolerances and comfort. These may include such simple means as giving him pure oxygen to breathe and diets of low solid waste (to reduce the body waste problem on flights of short duration) and complex means, greatly in need of further research, such as the administration of drugs.

However, regardless of efforts to prepare man for space flight, it is certain that man's body and performance ranges will be inadequate; it will be necessary to greatly modify the local environment to protect and sustain his life. The scientific community must give man in space a pressure capsule to retain his respiratory gases, a chemical and temperature conditioning system to maintain his oxygen and thermal balance, and radiation and meteor shields; must design him instruments, restraints, and controls to optimize the critical aspects of pilot read-in, decision making, and read-out; and may need to give him computers to speed his decisions.

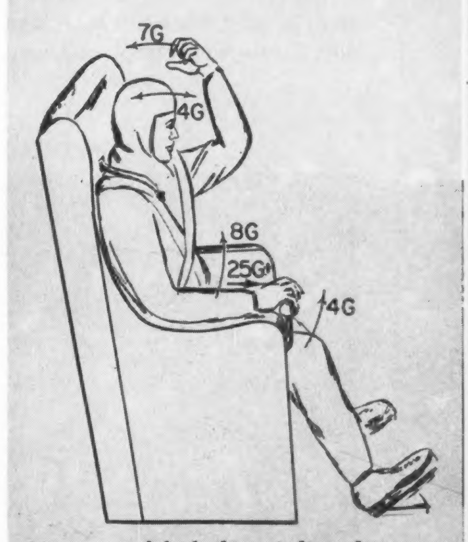
So far, there is little experience with the operation of the body for long periods near the limits of its ranges, so that, as a point of view, one should attempt to provide local environments as near to "normal" conditions as possible, and to utilize the extreme tolerance ranges only under emergency conditions. There are many problems to be considered. Attention must be directed to the morale aspects of the space environment, for example, with respect to crew personalities, number, sexes, and motivations, and with respect to amusements and communication. It may be possible, for instance, to send to the space crew commercial television and radio broadcasts. To reduce the sense of isolation, it will be desirable to augment in every possible way the feedback from the crew to the world behind. Exercise is also important in maintaining a sense of well being. With the absence of aerodynamic drag in space, it may be feasible for the spaceman to assemble a bar-mesh "jungle gym" on the back of his vehicle, and take his exercise away from the confinement of his cockpit. But these are almost byways compared with the problem of acceleration.

Long-duration acceleration is one aspect of space flight which cannot be filtered out or attenuated. Human acceleration tolerance sets a limit to manned vehicle performance. The determination of acceleration tolerance has thus led to major studies with huge centrifuges, such as the human centrifuge, with its 50-ft radius, at the Naval Air Development Center.

This centrifuge, shown on the opposite page, is designed to reach 40 g in 7 sec, and is provided with a power-driven double gimbal system, unique for human centrifuges, by which it is possible to program continuously the direction of the subject with respect to the resultant acceleration vector.



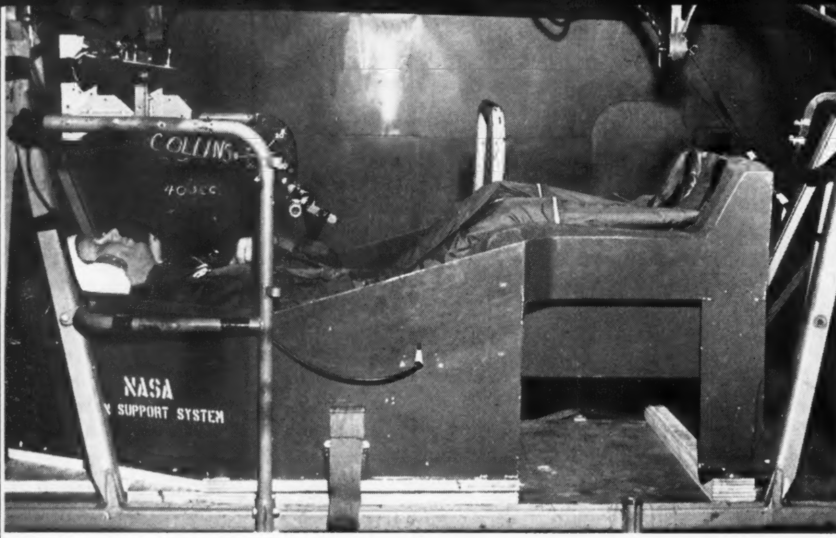
Physiological Acceleration Vectors



Movement of the body, as indicated by the arrows, is just possible at the accelerations listed.

## Defining Accelerations of Aircraft or Vehicle

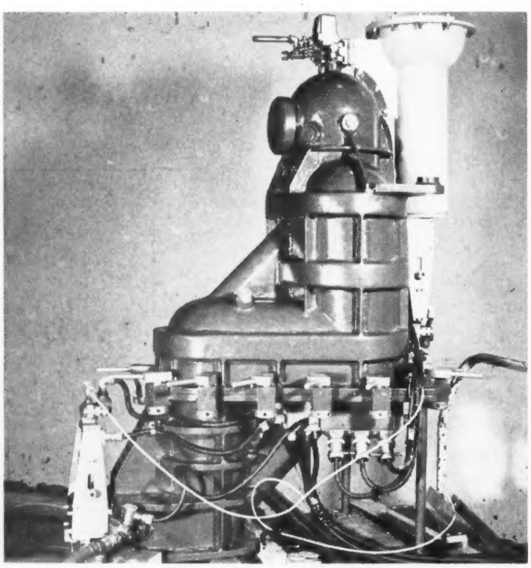
Here we should pause a moment and define acceleration. The figure at top right shows the right-hand orthogonal physiological acceleration vectors in use by AMAL, and indicates the direction of movement of the heart relative to the skeletal frame. The standard NASA terminology for accelerations of an aircraft or vehicle is a right-hand orthogonal set with vehicle $a_x$ positive and forward, vehicle $a_y$ positive to the right, and vehicle $a_z$ positive downward. With these definitions, physiological and vehicle accelerations have the same signs for the pilot sitting upright except for $a_z$: it is thus necessary to note that a positive vehicle $a_z$ produces a physiologically negative $a_z$ acceleration, as in an outside loop. Thus, for clarity, it is recommended that accelerations




The NASA Contour Couch

always be specified as *vehicle accelerations* or *physiological accelerations*. The accelerations referred to hereafter are physiological ones.

To have pilot read-out, it is necessary that the pilot move. The figure on page 19 summarizes motion capabilities while under acceleration. For vehicle accelerations of the magnitudes and directions shown, limb motions in the same directions are marginally possible. The ability to drag the heel along the floor depends critically on the friction between these surfaces. Drawing the foot back at an $a_x$ of $-5$ g is difficult but still possible. Note the ability to operate wrist and finger controls to an $a_x$ of $+25$ g. It seems likely that the distal part of the foot would have a similar capability. Speech is intelligible at a physiological $a_z$ of $+6$ g; at higher levels of acceleration the pilot is generally straining, which prevents clear enunciation.



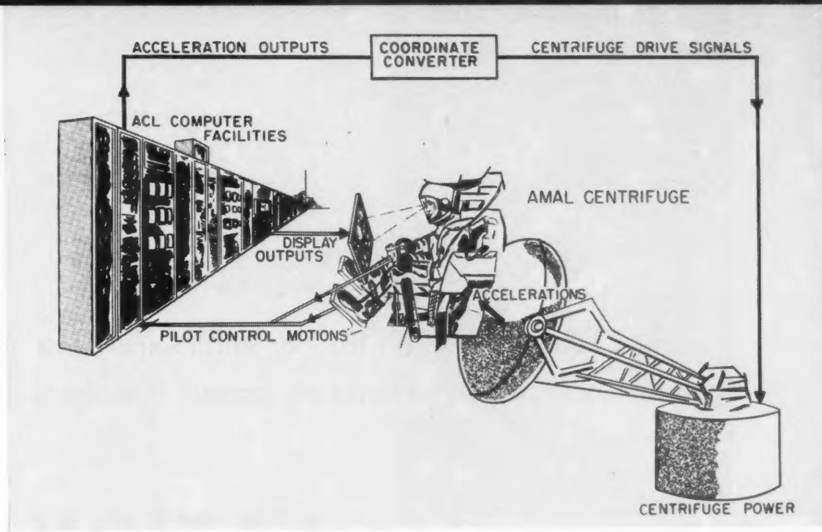
**In this water-filled g-capsule, which he designed in 1956, R. Flanagan Gray, riding the Navy centrifuge, withstood 31 g for 5 sec—a record for human tolerance to acceleration (back to chest).**

### Determining Tolerance to Acceleration

Human tolerance to acceleration is determined not so much by the force produced (divers can withstand the force of 20 atm of pressure) as by body distortion, particularly blood displacements, produced by the force. Tolerance is increased by preventing such displacement. For physiological positive $a_z$ acceleration, the greyout tolerance level of $+3$ to $+5$ g when relaxed may be increased 1 to 2 g by straining and 1 to 2 g by an antiblackout suit or immersion in water up to the chest, and up to 4 g if both straining and a g-suit are used. Other means to reduce body distortion will presumably increase g-tolerance.

Recent work at our laboratory in testing and development of an NASA idea has shown that by supporting the body in a contoured or body-mold couch, as shown in the photo at top left, a man in the slightly inclined chest-to-back position can reach an $a_x$ of $+25$ g without greyout, with a (1-cosine) waveform with a period of 40 sec. An important aspect in the attainment of this record was selection of back and head angles large enough to prevent chest pain, small enough to avoid blackout.

A re-evaluation of body distortion from acceleration was made by R. Flanagan Gray of this laboratory in 1955. He suggested that a principal site of blood pooling, particularly when the lower limbs and abdomen are compressed by a g-suit, is the lungs, and that air pressure within the lungs would prevent such pooling. To minimize body surface distortions, he chose to immerse himself in water,




**Dynamic control simulation with the Navy Centrifuge**

but with the vital addition (over work done during WW II by E. H. Wood, et al.; see OSR Report No. 207, Nov. 12, 1943) of complete immersion and lung pressurization. By the simple technique of complete immersion and holding his breath to attain lung pressurization as the chest compressed during acceleration, Gray set a new centrifuge record in April 1958 for $a_z$ tolerance of $+16$ g with a (1-cosine) waveform with a period of 25 sec. The physiological limit at 16 g was not greyout but the inability to voluntarily hold air in the lungs.

Gray had recognized that higher lung pressures would be necessary. For this reason, in 1956, he designed a seated-body-form aluminum g-capsule, subsequently built by the David Clark Co., as shown at the bottom of the opposite page. Gray's capsule has a closed respiratory system and is filled with water. The rigid container, when sealed, insures that the body maintains a constant volume. The respiratory system pressurizes the lungs enough to prevent them from distorting under forces of acceleration. Oscillation of pressure above the applicable base line maintains oxygen transport at constant volume.

Thus far, the water capsule has only been tested with the subject facing away from the center of rotation of the centrifuge. The acceleration in this position is back to chest, or $-a_x$. In this position, Lt. Comdr. Martin G. Webb, USN-MC, has reached a level of 28 g with a 1-cosine acceleration pattern of 28-sec total duration. More recently, Gray in this position has reached a peak level of 31 g, which was maintained for a period of 5 sec—a record for centrifuge acceleration tolerance for humans in this orientation.

During the run, Gray experienced a moderate amount of abdominal pain, which may have been due to compression of intestinal gases. Gray's arm and leg movements were free and he suffered little disturbance of vision. Due to the difference in density between the water and the thorax, the subject was moved strongly against the back of the capsule. This contact may have been the cause of minor back pain which he felt a day after the experiment. A complete physical examination revealed no apparent physical damage which could be attributed to the tests.

The high degree of protection Gray's capsule gives can be appreciated by a comparison of the condition of one of Col. John Stapp's subjects in the pioneering tests of accelerations of this magnitude carried out on the high-speed sleds at Holloman AFB (See *J. Aviation* (CONTINUED ON PAGE 88)

**Medical researchers are taking up the challenge of preparing man for space flight. Here, author Clark cheerfully takes a 2-g "trip to Mars" in 42 hr, in a first study of long-duration acceleration.**

Illustrations from "The Lonely Ones" by William Steig; Duell, Sloan and Pearce, New York; Copyright 1942.

Man may need much of his familiar earth experience reproduced in space vehicles to protect him from the stresses of. . .

# ISOLATION

*By Capt. George E. Ruff* (USAF-MC)

AERO MEDICAL LABORATORY, WADC, WRIGHT-PATTERSON AIR FORCE BASE, OHIO

George E. Ruff, a graduate of Haverford College and the Univ. of Pennsylvania School of Medicine, received his psychiatric training at the Univ. of Michigan and began his research career at Michigan's Mental Health Research Institute. Following this, Dr. Ruff was awarded a USPHS postdoctoral fellowship for training in neurophysiology and physiological psychology. He then entered the Air Force, and since August 1957 has been chief of the Stress and Fatigue Section of the Aero Medical Laboratory, Wright Air Development Center. His research there has dealt with stress in AF operations and development of stress measures, isolation, confinement, sensory deprivation, and crew selection.

FEW SOURCES of stress expected in space flight have been more widely discussed than isolation. In part, this reflects the broad range of topics to which the term has been applied. To a greater extent, however, interest in isolation arises from its significance as an area of universal human concern. The image of men alone thousands of miles from earth represents an experience everyone has felt to some degree.

Perhaps the crux of the problem is "aloneness"—a feeling of separation from other people. But this is only one aspect of isolation. Another is the sense of physical distance from others, which is not exactly the same as a feeling of psychological distance. A person separated geographically from those to whom he has close emotional ties may feel less alone than a man who lives in a large city but cannot form meaningful relationships to his fellow human beings.

In the absence of normal contacts with others, individuals commonly lose their sense of external reality and have difficulty maintaining a clear concept of inner identity. To a certain extent, a person tests reality and maintains identity by receiving cues from others. If there is no way for his actions and speech to produce a response from the environment, he may be unable to function normally.

A third aspect of isolation is cultural. Even one who has few direct bonds with others may be strongly related to his group or culture. These identifications are an important resource for withstanding stress. The Communist Chinese deliberately sought to make "social isolates" of prisoners of war to disrupt them.

Along with isolation from one's culture, we may consider the effects of separation from familiar surroundings. All of us live in a network of customs and experiences. We become so used to these that we are seldom aware of them. But, to the traveler or emigrant, their absence becomes an acute problem. Counseling services of any large university can provide illustrations of emotional breakdowns in foreign students who were unable to tolerate being cut off from familiar features of their native environment. Even numerous

friends and advisers cannot compensate for the absence of accustomed physical surroundings, gestures, and greetings; the lack of opportunities to gossip and argue over familiar topics; and the failure to hear one's native language.

Where more than one man is isolated, the nature of many of these problems changes and new difficulties appear. Group isolation studies in the Aero Medical Lab suggest that the constant, inescapable presence of fellow humans may potentially be as stressful as their absence. Arctic explorers and others have vividly described the disruption of groups whose members came to hate the sound and sight of their companions. These accounts tell of how men become acutely aware of each preoccupation of others in the group, and how minor habits can cause major conflicts. Lack of at least an occasional opportunity to withdraw from interpersonal conflicts is thus a potential source of difficulty for long space flights.

## Adjusting to an Artificial Environment

Another problem closely associated with isolation is that of living in and adjusting to an artificial environment. The solitary space traveler will find that many of the techniques he has employed for adapting to his usual world will be unavailable in an artificial setting. Not only will he be removed from his ordinary surroundings and from associations with other humans, but he will also be cut off from accustomed ways of using his environment to satisfy his needs. For example, to maintain emotional equilibrium, most people must preserve a balance between being dependent on some people and having others dependent on them. They may even have to be busy some of the time and idle at others, or to be sloppy part of the time and neat at others. Disruption of these accustomed patterns of behavior may be an inevitable part of life in a space vehicle.

Also related to isolation are the problems of enclosure and confinement. Restriction in space produces both physiological and psychological difficulties. Most people need some degree of physical activity to be comfortable. Many became anxious when forced to remain in a closed compartment. Added to this will be the knowledge that, once the mission begins, there is no way out.

Another area closely related to isolation is sensory deprivation, which has received wide attention since the appearance of reports from Hebb's laboratory that dramatic changes in behavior follow changes in the sensory environment. These studies dealt with subjects isolated in a small chamber, with arms and hands enclosed in cardboard sleeves. To reduce the patterning of sensory input, eyes were covered with translucent goggles and sound restricted to white noise.

## Suggestibility Increased

After a few hours in such a setting, subjects could no longer carry on organized, directed thinking. Suggestibility increased, and a strong desire for stimuli and activity appeared. Those who remained in the chamber long enough reported bizarre perceptual changes, hallucinations, and delusions. One man, for example, described "a procession of squirrels with sacks over their shoulders marching purposefully across a snow field." Another said, "My mind seemed to be a ball of cotton wool floating above my body."

To study reduction in the quantity of sensory input, Lilly has immersed subjects in a tank of water. Sound and light are eliminated by a blacked-out mask enclosing the head. Touch and pressure are absent. Even gravity is reduced. Under these conditions, stimulus hunger develops within less than an hour. Visual imagery (CONTINUED ON PAGE 110)

# Biodynamics of space flight

**Centrifuge studies indicate that man, although limited in position and movement during flight, can withstand the accelerations necessary to enter and return from space**

*By Edwin P. Hiatt*

AERO MEDICAL LABORATORY, WADC, WRIGHT-PATTERSON AIR FORCE BASE, OHIO

**Edwin P. Hiatt is head of the Aero Medical Lab Biophysics Branch. After receiving a doctorate from the Univ. of Maryland in 1940, he taught for a time at New York Univ. and then, in 1944, joined the staff of the Univ. of North Carolina School of Medicine as an associate professor of physiology. While at North Carolina, he received an M.D. from Duke Univ. in 1950. In 1957, he left the N.C. School of Medicine to assume his present position. Dr. Hiatt has also been visiting research professor in biology at Boston Univ.**

WHAT we know about the influence of relatively prolonged acceleration on human subjects has come mostly from the use of large centrifuges. It is easy to see how the centrifuge has been useful in the past in studying the accelerations encountered in aircraft making tight turns at high speed or otherwise changing direction in an arc, but we might spend a few words indicating how centrifuges are useful in studying the effects of prolonged linear accelerations, which have come to prominence with the development of rocket-driven vehicles.

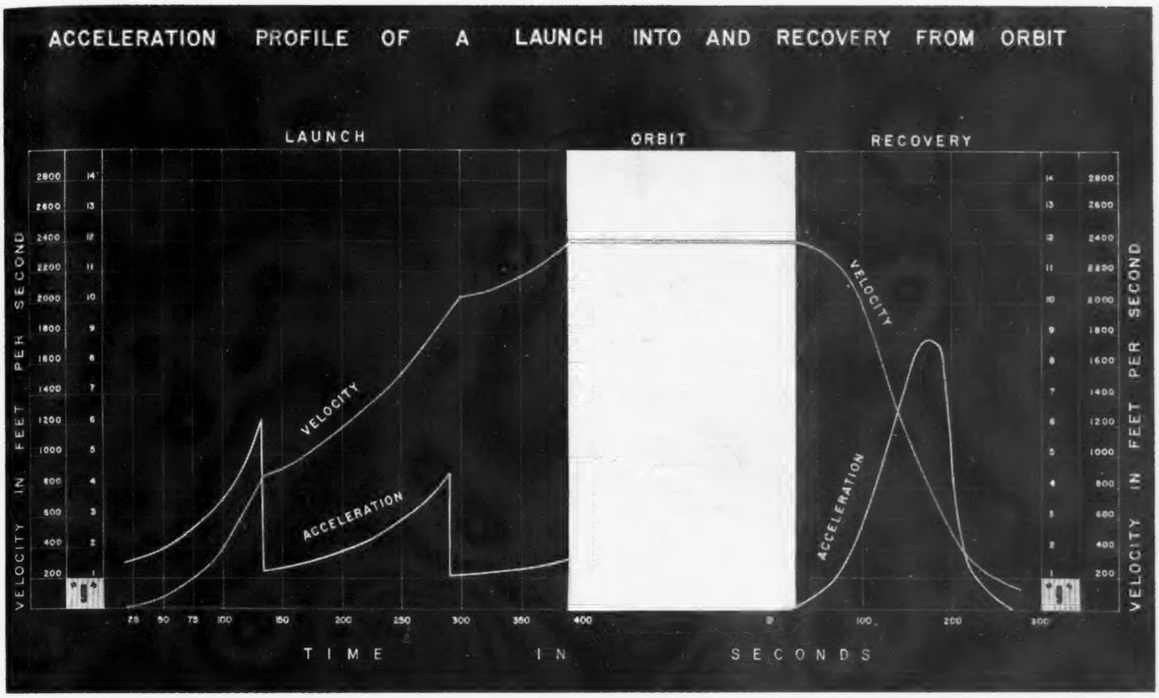
A man seated on the end of the arm of a centrifuge facing its axis is exposed to a forward (centripetal) acceleration comparable to the acceleraton a man would feel seated facing forward in a rocket vehicle. As he accelerates forward, he is pushed back into his seat with an inertial force proportional to his acceleration. If he accelerates at a rate of 32.2 fps/sec, or 1 g, he will be pushed back in his seat with a force equal to his weight, at 2 g twice his weight, etc. This inertial effect, which is responsible for most of the physiological consequences of acceleration, is opposite in direction to the acceleration, and is sometimes expressed with the same symbol as that used for acceleration, with the inertial effect understood.

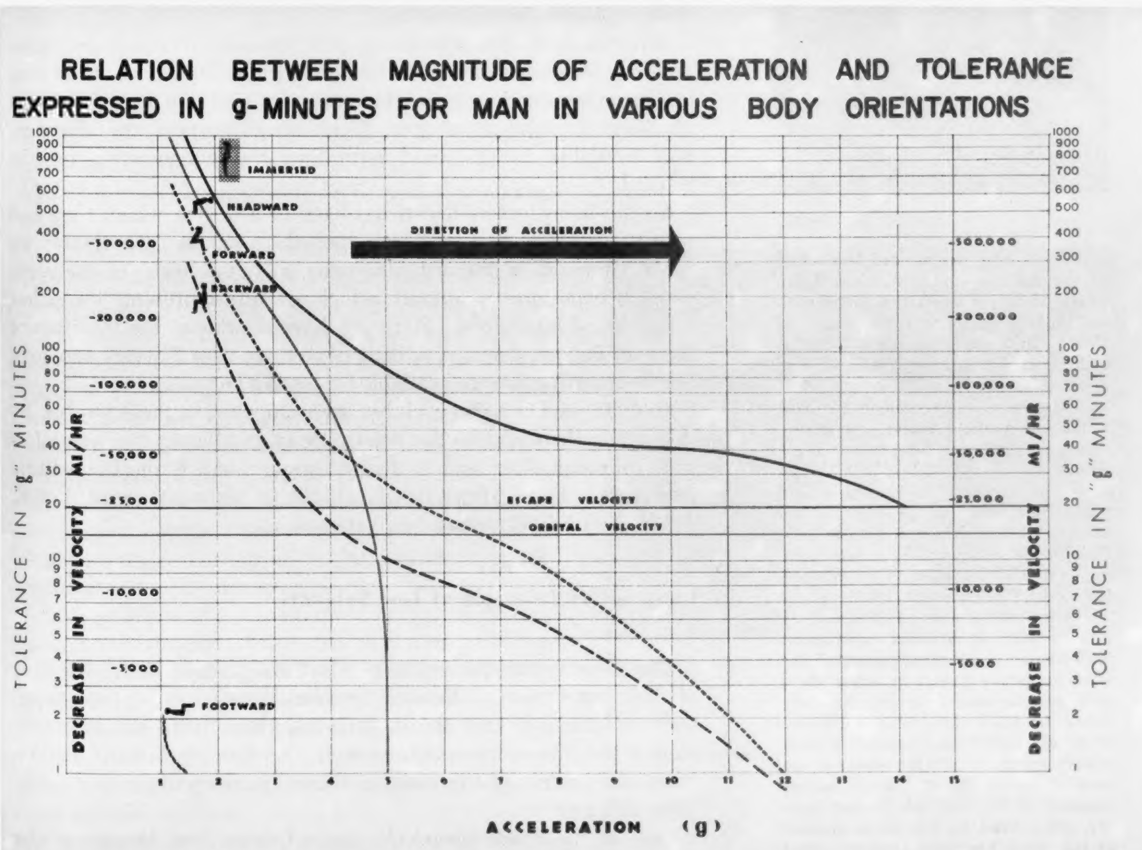
## Simulating Re-entry Conditions

By turning the man around on the centrifuge, we can accelerate him backward, thus throwing him forward against his restraint straps and simulating the condition of the forward-facing passenger in the rocket vehicle when he is decelerated as, for example, on re-entering the atmosphere after a trip out into space.

Similarly, we can arrange the man so that he accelerates headward, footward, laterally, or in any other direction. The chief advantage of using the centrifuge is that we can study prolonged acceleration of varying degrees and in varying patterns while remaining in one location convenient for the recording and measurement of effects. For example, we have run subjects at 3 g for an hour on the centrifuge.

There are some disadvantages in the use of centrifuges to study linear acceleration. One is the vertigo that results from the stimulation of the organs of equilibrium by the complex force pattern developed when the centrifuge changes rate (CONTINUED ON PAGE 70)


ACCELERATION PROFILE OF A LAUNCH INTO AND RECOVERY FROM ORBIT
LAUNCH
ORBIT
RECOVERY
VELOCITY
ACCELERATION
VELOCITY
ACCELERATION
VELOCITY IN FEET PER SECOND
VELOCITY IN FEET PER SECOND
TIME IN SECONDS


RELATION BETWEEN MAGNITUDE OF ACCELERATION AND TOLERANCE EXPRESSED IN g-MINUTES FOR MAN IN VARIOUS BODY ORIENTATIONS
IMMERSED
HEADWARD
FORWARD
BACKWARD
FOOTWARD
DIRECTION OF ACCELERATION
ESCAPE VELOCITY
ORBITAL VELOCITY
TOLERANCE IN "g" MINUTES
DECREASE IN VELOCITY MI/HR
ACCELERATION (g)

# Weightlessness and space flight

**Aeromedical aircraft experiments indicate that astronauts' difficulties will not lie in the weightless state itself, but rather in aggravation of other conditions, which, in combination, could pose problems**

*By Harald J. von Beckh*

AEROMEDICAL FIELD LABORATORY, HOLLOMAN AIR FORCE BASE, N.M.

Harald J. von Beckh, assistant chief of the AF Aeromedical Field Lab's Space Biology Branch, graduated with an M.D. degree from the Univ. of Vienna in 1940. Already a pilot at this time, his primary interest was directed towards aviation medicine. In 1941, he was assigned to the staff of the Aeromedical Academy in Berlin, where he lectured for student flight surgeons. Shortly after WW II he went to Buenos Aires, Argentina, where he lectured in postdoctoral courses at the National Institute of Aviation Medicine. He devoted the major part of his research activities to the study of human reactions to weightlessness and is remembered for pioneer work in airborne experiments with human and animal subjects. Besides numerous papers in aeromedical and aeronautical journals, he published in 1955 the textbook "Physiology of Flight" (in Spanish), a work which emphasized the medical aspect of space flight. An honorary member of the German Rocket Society, since 1952 he has been director of the Space Medicine Department of the Argentine Interplanetary Assn.

DURING the past quarter century, aeromedical investigators have with great ingenuity succeeded in simulating on the ground nearly all the conditions and stresses to which the pilot of an aircraft, or of a space vehicle, could be exposed. Gigantic human centrifuges and rocket sleds have been created which produce high accelerations at controlled rates of onset and decay. Elaborate low-pressure chambers now simulate any desired condition of temperature, humidity, and altitude, and can, under safe control, produce even explosive decompression.

Equipment of this type makes possible more thorough and more comfortable observation of the subject's physiological reactions than has been possible in the air. However, for studying one of the most challenging problems of space flight—weightlessness—no laboratory was available which could reproduce the phenomenon on the ground.

So the investigators had to go back to a device which they had nearly forgotten as a research tool—the aircraft. Therefore, we have witnessed in the last few years a "renaissance" of the aeromedical experimental aircraft, which actually represents the oldest aeromedical laboratory. Here, we have continued the tradition of the very first acceleration studies, done more than 25 years ago, long before centrifuges were available for testing humans.

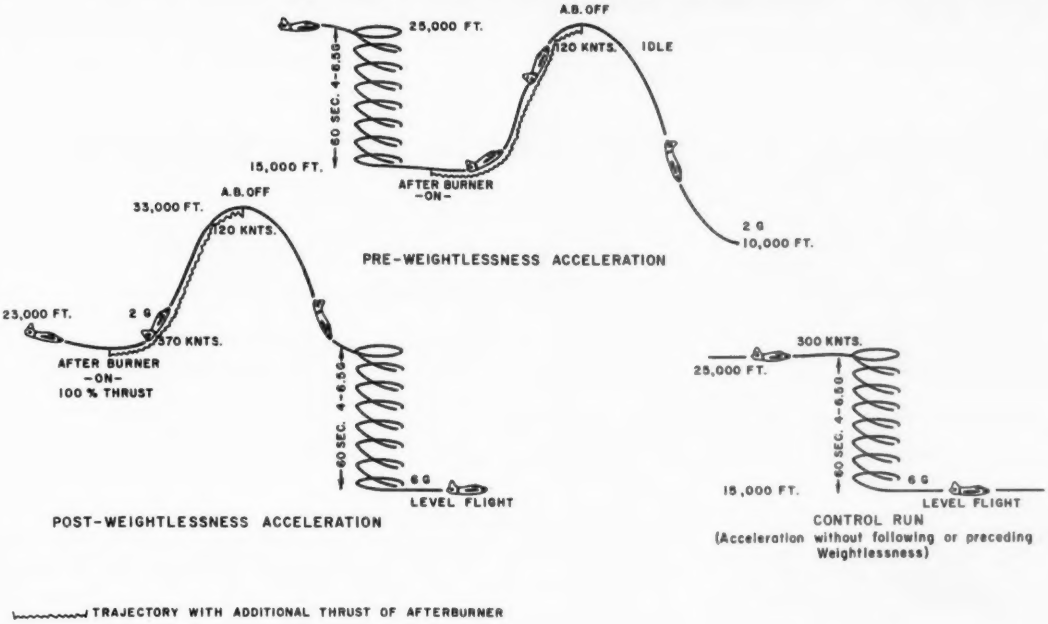
In 1950, Heinz & Fritz Haber gave impetus to these studies by describing theoretically the possibility of producing the weightless state for medical research by flying segments of a Keplerian ballistic trajectory. Soon afterwards, airborne experiments with F-80E, T-33A, and F-94C aircraft were started.

## Imaginative Selection of Test Subjects

The investigators proved to be most imaginative in the selection of their test subjects. Besides "cross-marking" and "stylus-aiming" tests on human beings, the ballistic-trajectory flying menagerie included the Rhesus monkey, as well as subtropical water turtles, while not excluding the more common quadrupeds, such as cats, dogs, and rodents.

One of the most intensively studied areas was *neuromuscular coordination* during the weightless state. Several eye-hand coor-

**Flight Patterns for Inducing Weightlessness**




dination tests were used for this purpose, including cross-marking tests (von Beckh, 1953), and stylus-aiming tests (Gerathewohl, 1956, and Lomonaco, 1956).

It was shown that neuromuscular coordination deteriorated in the weightless state and led to an "overshoot" in reaching maneuvers. However, the visual control of hand movements was sufficient to compensate for this overshoot and it was found that, after several attempts, aiming movements could be carried out satisfactorily. However, the possibility exists that immediately after burnout, and especially if the operator wants to reach a control without looking at it, he is likely to wind up at the wrong button. Therefore, it is desirable that human engineering experts make controls of space vehicles as foolproof as possible.

The problem of disorientation during weightlessness is very similar. It has been shown that, as long as the subject retains visual references (the horizon or instruments), disorientation rarely takes place. However, in all these experiments the subject was aware that he was about to enter the weightless state and could prepare himself psychologically for this unusual situation.

It seemed of interest, therefore, to observe a subject who finds himself (CONTINUED ON PAGE 84)

**Cockpit of F-94C Aircraft With Zero-G Instrumentation**

1. Recording switch
2. Aluminum foil
3. Oxygen regulator
4. Oscillograph
5. E.K.G.
6. Camera with wide-angle lens
7. Quick-release plugs for electrode leads
8. Dermo-ohmeter (GSR)

# Selecting a space cabin atmosphere

**A physiologist examines the carbon dioxide problem, the role of trace substances, and changes in the normal diurnal cycle for clues as to the type of atmosphere man needs to operate efficiently in space vehicles**

*By Karl E. Schaefer*

U.S. NAVAL MEDICAL RESEARCH LABORATORY, NEW LONDON, CONN.

**Karl Ernst Schaefer is head of the Physiology Branch of the Navy Medical Research Lab, New London, Conn. Born in Germany, he received his M.D. from the Univ. of Kiel in 1936, and was research assistant at the Physiological Institute in Heidelberg from 1937 to 1939. During the war, he carried out physiological studies at the German Naval Research Institute of Submarine Medicine in Carnac, France. After the war, he taught physiology at the Univ. of Heidelberg and served as acting director of the Physiological Institute from 1947 to 1949, editing the Herman Monograph on Submarine Medicine prepared under the auspices of the U. S. Naval Technical Unit. In 1949, he joined the Navy Medical Research Lab. Dr. Schaefer was instrumental in preparing the program for the First International Symposium on Submarine and Space Medicine, held last September in New London.**

SUBMARINE medicine has long been concerned with the problem of maintaining atmospheric conditions in a confined space which do not adversely affect the well-being and performance of its inhabitants. The situation which exists in submarines and sealed cabins in space vehicles is in many respects similar, although obvious differences exist insofar as weight and power supply are concerned. Nevertheless, experience gained in submarines can be drawn upon in any discussion of the selection of a sealed cabin atmosphere.

While many important aspects of the sealed cabin atmosphere have been described by D. G. Simons and E. R. Archibald and H. G. Clamann, we will deal here specifically with the carbon dioxide problem, the role of trace substances in the atmosphere and environmental time-givers.

In the older literature, 3 per cent carbon dioxide has been considered as the highest permissible concentration. This figure was based on short-time exposure. In repeated laboratory tests in which subjects spent 3–6 days in a "sealed cabin" in an atmosphere of 3 per cent $CO_2$ and 21 per cent oxygen, the author found that the subjects developed a definite decrease in their sensitivity to carbon dioxide, as indicated in their respiratory minute volume and alveolar carbon dioxide tension. The author has also found that 3 per cent $CO_2$ produces a biphasic reaction—that is, a period of excitation followed by depression, as demonstrated in subjective sensations, in tests of letter cancelling and hand steadiness, chronaxia measurements and changes in the EEG pattern. These two phases correspond with a period of uncompensated respiratory acidosis, followed by a period of compensated acidosis during which an increase in the alkali reserve of the blood occurs owing to retention of alkali by the kidneys.

Field tests carried out on submarines during war patrols confirmed the impairing effects of 3 per cent $CO_2$. Compared with values obtained in breathing surface air, exposure to 3–3.5 per cent $CO_2$ and 15–17 per cent $O_2$ during submergence produced: 1) Impaired response of the circulatory system to exercise; 2) fall in blood pressure; 3) decreased oxygen consumption; and 4) impaired attentiveness. Analysis of available data on the effect of lowered oxygen tensions led to the conclusion that the reduction in oxygen content

of the atmosphere was not a decisive factor in the development of the described effects.

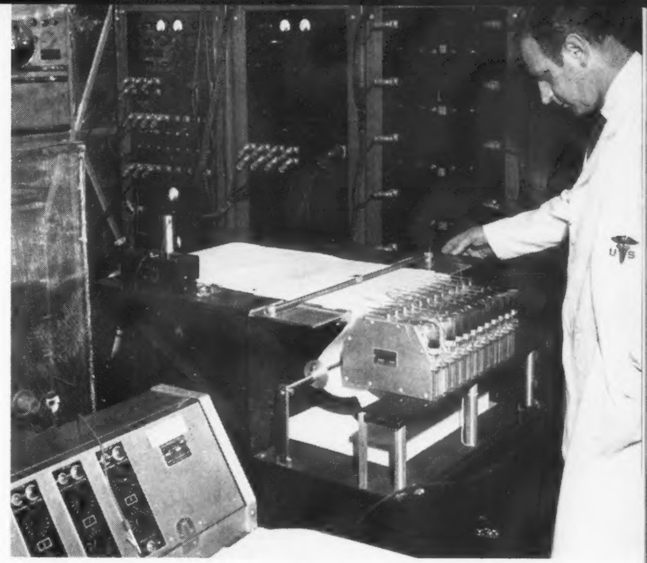
Carbon dioxide excretion via the lungs and the kidneys is considerably reduced during the uncompensated phase of respiratory acidosis. The respiratory exchange ratio is therefore lower than normal during this period. This has an important bearing on considerations of an equilibrium between human respiratory metabolism and $CO_2$ removal systems in a sealed space cabin, usually based on a normal respiratory exchange ratio (RQ) related to food intake.

If subjects are exposed to $CO_2$ concentrations below 2 per cent for prolonged periods, acid-base balance regulation is so slow that it takes approximately three weeks until the slight respiratory acidosis is compensated, as described by G. Nichols, et al. Animal studies confirm the time dependence of such regulation, determined from the kidney. With higher concentrations, the compensation phase is attained after shorter times. Carbon dioxide concentrations which produce even a slight respiratory acidosis and make physiological compensation necessary should be avoided, even if no impairment of performance can be detected under these conditions with conventional psychomotor tests. Humoral regulation involving electrolyte exchange takes a long time during adaptation to low concentrations of $CO_2$, as well as during the recovery periods which follow, the latter amounting to more than four weeks. To avoid extended leave periods after $CO_2$ exposure, concentration must be held between 0.5 and 1 per cent.

## Cabin Pressure a Major Factor

Acceptable levels of oxygen and nitrogen in the sealed-cabin atmosphere depend on the pressure chosen for the cabin. Design engineers have favored a reduced pressure inside the cabin to decrease the pressure differential between the interior of the cabin and the vacuum of space, thereby minimizing unavoidable leakage of cabin air. Recent findings of J. A. Van Allen and his associates regarding the radiation belt around the earth have produced additional requirements for satellite shielding. In a recent analysis of the newly developed situation, I. Cooper has demonstrated that the maintenance of one atmosphere in the sealed cabin has a negligible effect on the weight stress requirements for shielded sealed cabins. These circumstances allow normal atmospheric pressure and consequently normal levels of oxygen and nitrogen.

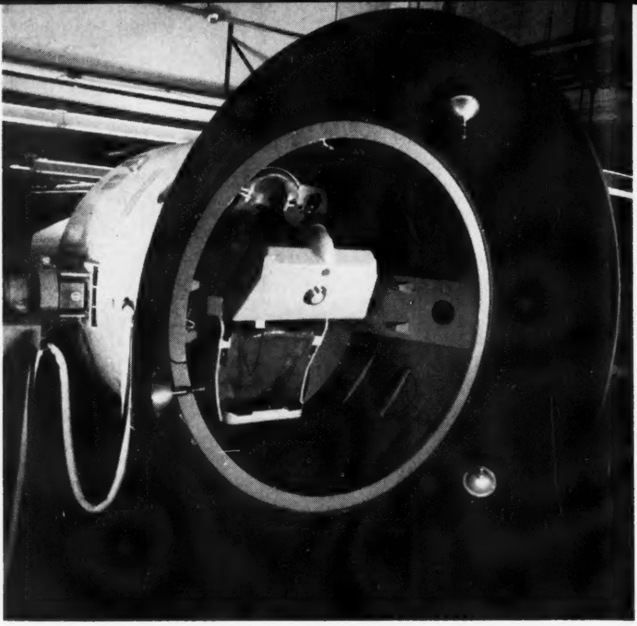
Considerations for heavier shielding do not apply for altitudes up to 400 miles, below the radiation belt. Under these conditions, normal atmospheric pressure may not be maintained in the cabins of unshielded satellites and we have to concern ourselves with the lowest and highest permissible oxygen concentration and the problem of whether or not nitrogen is an essential, irreplaceable component of the atmosphere.



**Man-in-space plans are drawing heavily from experience with the submarine for obvious reasons. The author appears here with part of the instrumentation for Operation Hideout, the first long-range "sealed-cabin" experiment made at the New London submarine base. In this experiment, conducted in 1953, 20 men stayed in a submarine for eight weeks.**

In summarizing available data and experiences from the Himalaya expeditions, G. Pugh came to the conclusion that the altitude ceiling height to which man can permanently adapt himself while breathing natural air is approximately 19,000 ft (corresponding to 7.04 psi). Temporary partial acclimatization to 15–16,000 ft (8.3–7.96 psi) can be reached within three or four days, according to B. Balke. U. Luft notes that the threshold altitude for development of hypoxic symptoms in unacclimatized subjects is between 8000 and 10,000 ft, although he adds that inhalation of pure oxygen can raise the ceiling height to 39,000 ft (3 psi). However, exposure to 100 per cent oxygen can only be tolerated for a limited time.

Few investigations have been carried out with prolonged exposure of men to increased oxygen concentration at altitude. Becker-Freyseng and Clamann did not find any significant impairing effects in subjects after a three-day exposure to 80–90 per cent oxygen at 30,000 ft. In recent experiments carried out in the Naval Air Crew Equipment Lab under the direction of Capt. Charles F. Gell (USN-MC), six men were confined in a sealed cabin for seven days at the equivalent of 10,000 ft altitude with an oxygen partial (CONTINUED ON PAGE 104)



GE Missile and Space Vehicle Dept. space capsule.

# Capsule for man in space

## GE shows manned satellite developed under AF study contract

WHAT kind of capsule will be used to send man into space and bring him back safely?

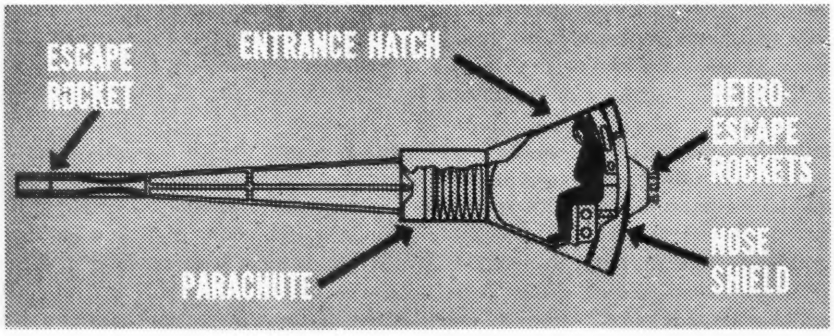
As NASA considered bids for the first manned satellite, one suggestion as to what form the capsule might take came from General Electric Co., which recently showed designs prepared for the Air Force Phase I capsule study program, allowed to lapse when NASA took over the man-in-space effort. The designs are of particular interest since information from the studies (made by both GE and North American Aviation) has been made available to NASA and was reportedly used in drawing up specifications for its capsule.

First details concerning the GE capsules, as well as the concepts involved in their design, were revealed by GE Missile and Space Vehicle Dept. general manager H. W. Paige in the Franklin Institute Redding Lecture in Philadelphia in mid-November.

In his address, Paige noted that the principal problem in preparing for man's first venture into space is that of reliability and safety of the occupant. The requirement for basic system simplicity of the vehicle is typified by the choice of the purely ballistic type of vehicle, the simplest approach known and the type currently in use for the ballistic missile program.

Paige added that Atlas would very likely be chosen to boost the manned satellite into orbit, and this has since been confirmed, at least unofficially, by NASA. In every possible area, he went on, components which have proved successful and reliable in current nose-cone programs would be used. Where components themselves would not be directly applicable, proven (CONTINUED ON PAGE 74)

**NASA Manned Satellite Proposal**



**Looking for all the world like one of science fiction's "bug-eyed monsters," early Soviet high-altitude suit is modeled by a typical subject.**

# Soviet biological experiments

## Russian physiologist notes successful Sputnik II and high-altitude rocket experiments with animals but denies knowledge of human rocket experiments and says no effort was made to return Laika to Earth

*By Irwin Hersey*

IN ANY broad discussion of man in space, neglect of the Soviet manned space flight program would be a glaring oversight. Questions as to the progress the Russians are making, where their program stands vis-à-vis our own and when they will succeed in putting a man in space are, of course, difficult to answer, for almost the same reluctance to provide information is found in this area as in the field of Soviet rocket and missile technology.

Almost, but not quite—for, at the Third European Congress of Aviation Medicine at Louvain, Belgium, last September, a leading Soviet physiologist, Andrei G. Kousnetzov, presented the first full-scale public rundown on Russian biological experimentation in this field. While the paper presented by Kousnetzov, who is chief of the Physiology Dept. of the Soviet Air Force Scientific Research Experimental Institute of Aviation Medicine in Moscow, was itself of great interest, the questions and answers which followed were even more enlightening.

In response to a series of questions by Col. John P. Stapp, chief of the USAF Aero Medical Laboratory, Dr. Kousnetzov revealed:

1. That no attempt had been made to catapult and parachute Laika from Sputnik II.
2. That there have been no Soviet rocket experiments involving human subjects "as far as is known."
3. That he had no personal knowledge of Soviet balloon experiments with human subjects or animals similar to the U.S. Manhigh Project.

In response to a query by Capt. Neville P. Clark of the USAF Veterinary Corps regarding the time and cause of death of Laika, Dr. Kousnetzov explained that the experiment was programmed to get information about the animal for seven days, after which power gave out and telemetry data was no longer transmitted. From signals received earlier, he noted, Russian scientists learned that regeneration of air had stopped, leading to the conclusion that the animal had died from hypoxia or lack of oxygen. He did not say when this had occurred.

### Gas Composition in Capsule

A question by Capt. Clark about cabin pressure and gas composition in the capsule used for the experiment brought a reply that the system used for oxygen regeneration maintained the composition of the gas "near the terrestrial one."

Dr. Kousnetzov began his paper by briefly reviewing the history of Soviet experimentation of this type, noting that investi- (CONTINUED ON PAGE 80)

# Psychophysiological aspects of Manhigh

**Balloon trips under space-equivalent conditions focus attention anew on the *whole* man as subject and author of space flight**

*By Lt. Col. David G. Simons* (USAF-MC)

AERO MEDICAL FIELD LABORATORY, HOLLOMAN AIR FORCE BASE, N.M.

**David G. Simons is now assistant chief of the Aero Medical Field Lab, which is responsible for conducting the AF program on the biological hazards of radiation at high altitudes. Graduated with an M.D. degree from Jefferson Medical College in 1946, he joined, after his internship, the Aero Medical Laboratory at Wright Field, where he served as project officer for rocket experiments on the physiological response of monkeys to weightlessness. In 1949–50 he attended the school of advanced courses in aviation medicine at the School of Aviation Medicine, Randolph AFB, Tex., and then was assigned for 2½ years to the Korean theater of operations. On his return from Korea, he was assigned to Holloman, later becoming chief of the Space Biology Branch of the Aero Medical Field Lab and gaining recognition for his contributions in the fields of animal experiments with sounding rockets and the Manhigh project. Col. Simons was the pilot on the record-breaking 32-hr Manhigh II flight, which took him to an altitude of more than 100,000 ft.**

MANHIGH I and II, conducted in June and August of 1957, explored the problems man faces living 24 hr under space-equivalent conditions. Manhigh III on Oct. 8, 1958 applied the lessons learned from these two flights to explore problems of manned-satellite flight. These Manhigh flights provided a previously unequalled opportunity to study psychophysiological reactions of an individual to the problems and stresses of living in a space-equivalent situation.

Psychophysiology emphasizes the natural interrelationship between psychology and physiology in human performance. George E. Ruff (see page 22) has pointed out the complementary nature of the two areas—noting that psychological tests indicate kind of stress present but seldom determine degree, and that physiological tests, on the other hand, indicate how much stress but not what kind.

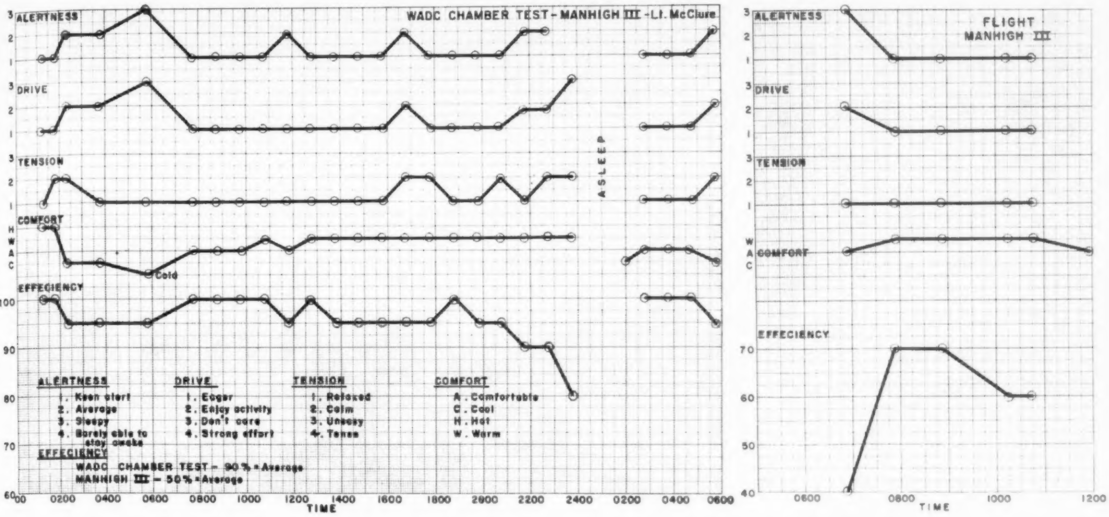
James P. Henry, a pioneer in the field, has aptly described psychophysiology as "the task of developing correlations between the findings of psychology and the patterns and systems that new techniques are uncovering in the central nervous system."

In the Manhigh program, simultaneous psychological and physiological measurements were used for pilot selection, and were then repeated during flight for comparison.

The pilots for Manhigh I and II flights, Capt. Joseph Kittinger and the author, took a series of qualification tests rather than a battery of selection tests. At first, the same approach was used for the Manhigh III.

Then Gen. Don Flickinger suggested that several candidates be trained for the flight and that each candidate be required to meet an age qualification, pass a battery of selection tests, and meet the kind of psychological and physiological qualifications that may be required of space crews.

Consequently, in addition to a routine Air Force flight physical, each candidate for Manhigh III took an exhaustive four-day physical evaluation at the Lovelace Clinic, Albuquerque, N.M. and a claustrophobia test at Holloman AFB. In the latter, each candidate was enclosed for 24 hr in a metal can having the same dimensions as the Manhigh capsule, and had to monitor test meters continuously during this period. In this testing, all communication was by interphone; the candidate was allowed to sleep for short periods, as



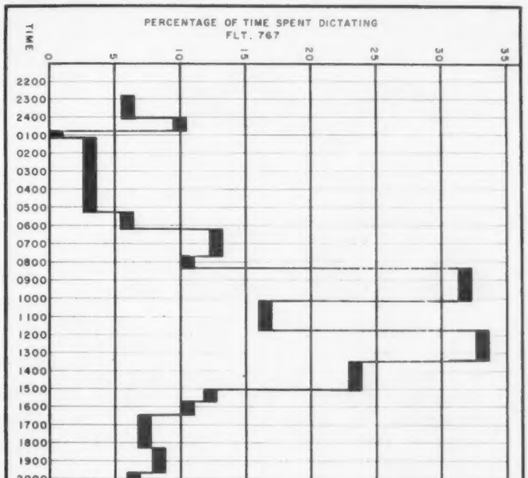

In Manhigh III, the pilot, Lt. McClure, gave a subjective grading of his alertness, drive, tension, comfort, and efficiency. Left, results from a chamber test at WADC; right, the actual flight in which the pilot became overheated at noon.

permitted in a balloon flight, but he was encouraged to remain active; and the same psychological and subjective tests for the actual flight (except psychiatric interview) were used throughout the trial, including regular recording of heart action, basal skin resistance, blood pressure, and respiratory rate.

## Individual Evaluation of Candidates

Moreover, three forms of individual evaluation—including an isolation and psychiatric evaluation, a psychophysiological "tiger-bunny" test, and a simulated flight in the Manhigh capsule—were conducted on all Manhigh III candidates at WADC. The total psychiatric evaluation included a full day of tests by a clinical psychologist, a psychiatric interview by two different psychiatrists, and a session in the "block box," a soundproof, unlighted chamber. Each candidate remained in this dark, silent world until he elected to leave. The "tiger-bunny" test indicated whether an individual reacted as a fighting tiger or running bunny when subjected to various combined stresses, which were induced by a series of centrifuge exposures to positive acceleration, a hot box (155 F and 85 per cent relative humidity) for 1 hr, pressure breathing, and immersion of the subject's feet in ice water.

The procedures in Manhigh I and II formed a general backdrop for this testing and changes introduced in Manhigh III. In both Manhigh I and II, measurements were made of capsule temperature, humidity, and internal pressure. The pilot operated instruments to determine the concentration of life-giving oxygen and (CONTINUED ON PAGE 62)



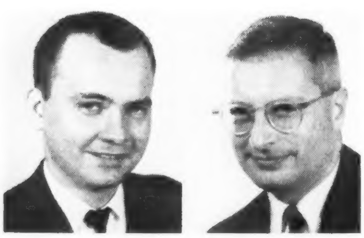

Time spent dictating to the tape recorder in Manhigh II, as shown above, was developed as a "creativity" index, which may indicate interplay of the pilot's physiology and psychology.

# Water recovery in a space cabin

## Simple distillation of urine and wash water from a sponge at room temperature could yield potable water for man in space

*By R. A. Bambenek and J. D. Zeff*

AMERICAN MACHINE AND FOUNDRY CO., CHICAGO, ILL.



Bambenek Zeff

**R. A. Bambenek is supervisor of the AMF Mechanics Research Dept. heat and thermodynamics group. After receiving M.S. in mechanical engineering and Master of Gas Technology degrees from Illinois Tech in 1954, he joined Rocketdyne, where he did research on high-frequency combustion instability and two-phase propellant flow. In 1956 he went to G.E. at Cincinnati, where he conducted studies of ignition of monopropellants and performed a heat-transfer analysis of the Vanguard first-stage rocket engine.**

**A research engineer for AMF, J. D. Zeff received a B.S. in chemical engineering at Purdue Univ. in 1947. Prior to joining AMF, he was with Gillette's Toni Div., in charge of chemical development and production, and Wilson's Pharmaceutical Div., in charge of Special Products.**

**At present both authors are engaged in an extensive AMF program for WADC to develop a unit for recovering water from human waste.**

KEEPING payload weight low is a prime requirement for rocket-powered flights into space. For each type of mission, a specific vehicle and associated subsystems must be selected to minimize energy expenditure. One subsystem which is gaining prominence is a closed ecological system—"closed" meaning that the materials necessary for sustaining life are recovered or regenerated. An "open" ecological system is one in which all materials are stored and discarded when used. An average man requires each day approximately 2 lb of oxygen, 5 lb of water for consumption, 4 lb of water for adequate sanitation and 1 lb of concentrated food. An open system, therefore, would require 12 lb of stores per man a day.

### Developing Ecological Systems

The development of a completely closed ecological system which is light in weight, small in volume, and economical of energy is still a few years away. To regenerate oxygen and food, or grow food such as algae in sufficient quantities, poses several problems which have not been satisfactorily overcome. Actually, these materials are required in relatively small quantities and therefore cannot be advantageously regenerated for missions shorter in length than interplanetary flights.

Water constitutes most of the waste in an open system. Therefore, a partially closed ecological system, one that recovers only water, is the first system that can be advantageously used for space flight.

The table on the opposite page indicates the sources of water which make up human water balance. Since the atmosphere within a space capsule will be treated to remove carbon dioxide, heat, and water vapor, water which comes from the lungs and skin will be collected by this system. This water has experienced a change of phase and will therefore contain very little contaminant. Possible impurities are those with vapor pressures similar to water, but these can be removed by charcoal filtration. Chemical sterilization can also be performed easily.

To recover potable water from urine and feces is a more difficult task. Actually, feces can be omitted, since the body produces more than enough water per day in other forms. Therefore, a water recovery system need only recover water from urine and

any wash water used. The table at right gives a typical analysis of urine. Recovery of water from wash water requires techniques similar to those for urine.

A spaceship system should give a high percentage of recovery of water of sufficient purity to drink, should require minimum energy for operation, and should impose no complicated handling problems in a zero-g environment. Laboratory tests have been made of several methods for purifying urine and feces: Freeze drying (sublimating water and then condensing water vapor as ice at low pressure –below the triple point of urine); distillation, both at atmospheric pressure and in partial vacuum; adsorption filtration and ion exchange; refrigeration; and electrodialysis. All these methods recover large percentages of water from urine and wash water, but with varying degrees of carryover.

Of the techniques evaluated, those employing a change of phase appear to be the most successful with present technology. Thus, freeze drying or distillation will be the processes utilized in the first water recovery system for a space vehicle. These processes also allow recovery of water from feces without modification of the fecal state, but they require additional operations to remove any turbidity, ammonia, odors, and bacteria present. Fortunately, these operations can be accomplished in the handling processes.

Refrigeration is the one technique which does not appear practical for water recovery in a space vehicle. To achieve a high yield of potable water requires recycling of the raw material, and hence complicated and weighty equipment.

Adsorption filtration and ion exchange can be made very selective in contaminant removal and are therefore most suitable for final purification operations. Also, they can be introduced in manual or automatic handling procedures.

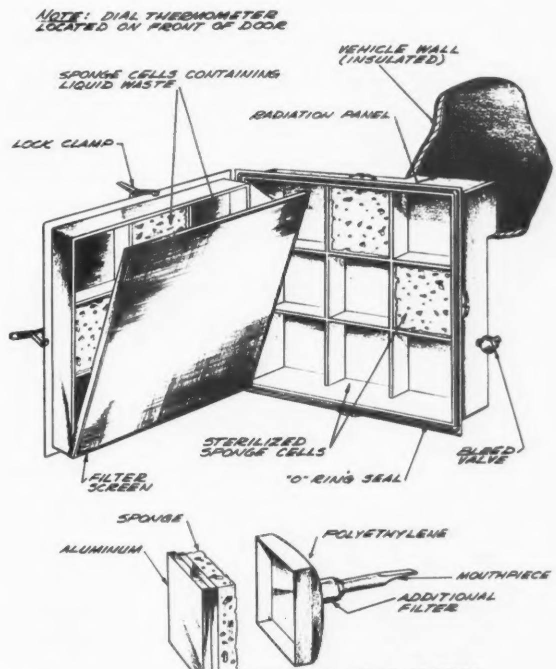
Electrodialysis is advantageous if energy must be minimized, since only the work of separation and cell resistance is required. (CONTINUED ON PAGE 112)

**Water Balance For Average-Size Man**

| Source | | Excretion | |
|---|---|---|---|
| Fluids of diet | 1200 gm | Lungs | 500 gm |
| Food | 1000 | Skin | 500 |
| Tissue oxidation | 300 | Urine | 1400 |
| | | Feces | 100 |
| Total | 2500 gm | | 2500 gm |

Note: Wash water required estimated at 1800 gm/man-day.

## A Distillation Water-Recovery System



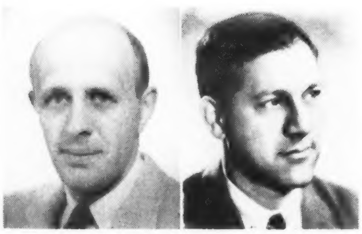

**Chemical Composition of Urine**

| Constituent | % By Weight |
|---|---|
| Water | 95.24 |
| Urea | 2.38 |
| Hippuric Acid | 0.05 |
| Uric Acid | 0.05 |
| Creatinine | 0.09 |
| Indican (Idoxyl Potassium Sulfate) | Trace |
| Oxalic Acid | do |
| Allantoin | do |
| Amino Acid Nitrogen | do |
| Purine Basis | do |
| Phenols | do |
| Cl as NaCl | 0.95 |
| Na | 0.32 |
| K | 0.16 |
| Ca | Trace |
| Mg | Trace |
| Sulfur, total as S | 0.08 |
| Inorganic sulfate as S | 0.06 |
| Neutral sulfur as S | Trace |
| Conjugated sulfates as S | Trace |
| Phosphate as P | 0.09 |
| Ammonia | 0.05 |

# A closed-cycle breathing / ventilation system

By supplying a proper microenvironment, advanced equipment of this type could sustain man in his first brief ventures into space

*By Walter B. Moen*, AIR REDUCTION CO., INC., MURRAY HILL, N.J.
*and Paul Webb*, WADC, WRIGHT-PATTERSON AIR FORCE BASE, OHIO



Moen Webb

**Walter B. Moen is assistant director of metallurgical research at the Central Research Labs of Air Reduction Co. A mechanical engineer, he holds a B.M.E. from Pratt Institute and an M.S. from Columbia Univ. With Airco for 10 years, he has engaged in research and development in combustion and propulsion, medical equipment and breathing systems, welding, and process metallurgy. He is a member of ARS, ASME, and the American Welding Society.**

**Paul Webb is chief of the environment section of the Aero Medical Lab at WADC. Following graduation with an M.D. from the Univ. of Virginia in 1946, and internships and Army service, he began a research career in environmental physiology at the Univ. of Washington, where he received an M.S. in physiology. Then, for two years, he was assistant professor of physiology at the Univ. of Oklahoma School of Medicine. Since 1954, Dr. Webb has been at the Aero Medical Lab, where his research interests have centered around the effects of extreme cold and heat, and on the development of ventilated clothing for heat protection. Among several affiliations, he is a member of ARS and a Fellow of AAAS.**

SPACE vehicles and some future aircraft will require an artificial atmosphere for the crew. A self-contained closed-cycle breathing/ventilating system can provide such an atmosphere without introducing the large weight and size of a conventional open system.

For this reason, the Air Force, through a contract with the Air Reduction Co. monitored by the Aero Medical Laboratory, began some time ago the development of a closed system, and now has a working version of such a system, shown at the top of the opposite page.

This closed-cycle breathing/ventilating system gives some idea of the kind of equipment that may serve in the first space vehicles, as well as in aircraft intended for flight above an altitude of 70,000 ft.

What must such a closed system do for a man?

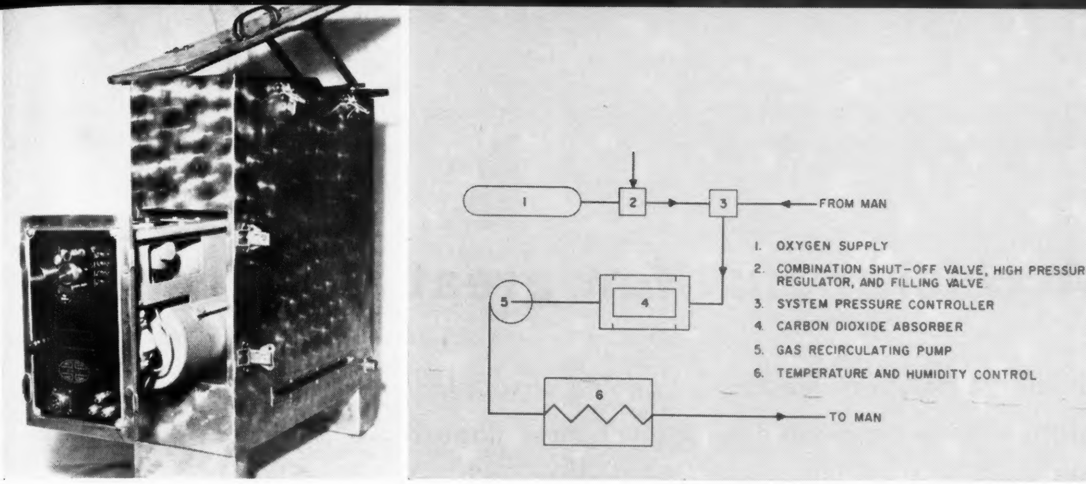
First, certain physiological requirements must be satisfied, so that man's biological processes will not be unbalanced. The establishment of an oxygen supply for support of metabolic processes; the removal of the products of metabolism—carbon dioxide, water, heat, odor, and toxic gases; and the maintenance of a satisfactory ambient pressure are all of concern.

There is much published literature on the rate of oxygen consumption and the effects of excesses and deficiencies of oxygen on performance. It has been established that, over protracted periods, including varying activity levels, the average oxygen consumption by an aircraft crewman is 0.10 lb/hr, with a coincident exhaust of 0.14 lb/hr of $CO_2$.

## Low Pressure Causes Hypoxia

Ambient pressure below 14.7 psia causes hypoxia, which lessens the ability of a man to act and lowers his efficiency. Hypoxia, however, may be prevented by oxygen enrichment of air at reduced total pressures, such that a minimum oxygen partial pressure of approximately 3.1 psi (160 mm Hg) is maintained. Another effect of reduced pressure is decompression sickness (bends or aeroembolism). Its occurrence is not likely below 25,000 ft altitude (5.45 psia), but above 30,000 ft it occurs with increasing frequency.

With these two prime considerations in mind, a 5 psia minimum




**Experimental closed-cycle breathing/ventilation system, with flow diagram.**

ambient pressure was deemed sufficient protection against aeroembolism, while providing sufficient oxygen pressure.

A conventionally clothed pilot cannot be made comfortable in all the situations he is likely to encounter in high-performance aircraft. However, tests have indicated compromise conditions which the pilot can endure for long flights.

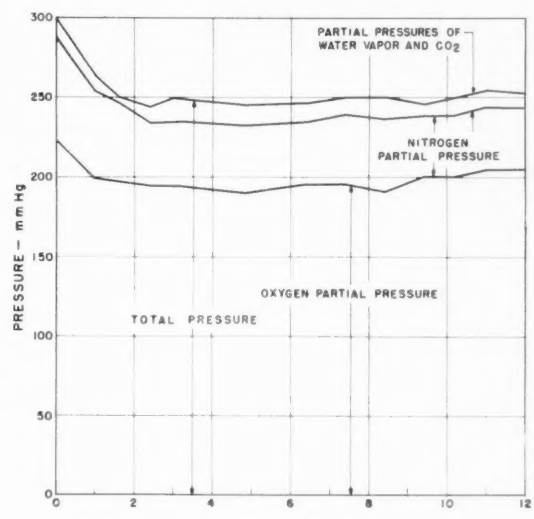
For instance, flight clothing, such as pressure and anti-exposure suits, includes a ventilating system to deliver conditioned air to the man at a rate of 10 cfm. The inlet-air temperature to a ventilated garment is usually fixed somewhere between 60 and 90 F, with a maximum discharge temperature of 130 F at the suit outlet. An inlet-air dew point of 45 F is chosen to be sufficiently low that a maximum sweat-production rate of 2.2 lb/hr can be handled.

## Effects of Odors

There is a dearth of literature on the physiological effects of the odors produced by man. It does not appear, however, that the slow buildup of his own odors has a deleterious effect on man, at least for periods of one or two days. The toxicity of his high-vapor-pressure waste products has not been documented, but certainly some of the volatile substances which escape through the skin and lungs will be a problem over a long period of time. For example, urea and several volatile amines have been found in small amounts, and these could eventually build up to toxic levels.

Protection against special hazards to man in space still are being investigated. Such considerations as ozone, radiation, and acceleration are not truly a part of a breathing/ventilation system, and will not be discussed here. However, the provision of an adequate air conditioning system, whether a man is in a suit or cabin, is a necessity. Pressure, of course, is determined (CONTINUED ON PAGE 102)

**The system goes into "space" in an environmental test chamber during a development experiment. Below, typical gas analysis for a 12-hr experiment.**



# Acceleration: How great a problem?

Studies to date indicate man is capable of withstanding the acceleration forces anticipated for present three-stage rocket systems, but there is very little likelihood that he will enjoy the ordeal

*By Col. John P. Stapp* (USAF-MC)

WRIGHT AIR DEVELOPMENT CENTER, WRIGHT-PATTERSON AIR FORCE BASE, OHIO

**As chief of the Air Force's Aero Medical Lab, Wright Air Development Center, Col. John P. Stapp is playing a major role in the man-in-space program. Holder of four degrees, including a Ph.D. from the Univ. of Texas in 1940 and an M.D. from the Univ. of Minnesota in 1944, Col. Stapp is perhaps best known for the rocket-sled human deceleration studies at Edwards AFB and Holloman AFB which earned him the title of "the world's fastest human" and won him a Legion of Merit and Commander's Order of the Legion, as well as many other honors, including the ARS James H. Wyld Memorial Award in 1955 and the Air Force Assn. Power Award for Science in 1954. Long active in ARS, he was elected National President at the 1958 Annual Meeting in November.**

IF NO better means for sending man into space can be devised than the present three-stage ballistic rocket systems used for putting satellites into orbit, will he be capable of withstanding the acceleration forces to which he will be subjected in these vehicles?

On the basis of studies to date, it may be said that man can endure the accelerations anticipated for attaining orbital or escape velocity in such vehicles if he is optimally positioned for the ordeal, and that he can also sustain the prolonged exposure to low acceleration required for re-entry. However, he is scarcely likely to enjoy either of these ordeals until such time as the design and operation of space vehicles advances to the point of complying with parameters of human effectiveness, rather than imposing on survival limits.

Before examining man's ability to withstand the accelerations of space flight, let's take a quick look at these forces.

To achieve a circular orbit 200 to 250 km (125–155 miles) above the Earth's surface, an artificial satellite must be accelerated to a velocity of approximately 8 km/sec (4.97 miles/sec). This would require a calculated constant acceleration of 828 g sec. To achieve escape velocity, the satellite would have to be accelerated to a velocity of 11 km/sec (6.83 miles/sec), and 1152 g sec of calculated constant acceleration would be needed.

Orbital and escape velocities within 2 to 10 min of calculated constant acceleration would necessitate the following g-time exposures:

| Minutes | G's to Orbit | G's to Escape |
|---|---|---|
| 2 | 6.9 | 9.6 |
| 4 | 3.45 | 4.8 |
| 6 | 2.3 | 3.2 |
| 8 | 1.73 | 2.4 |
| 10 | 1.38 | 1.92 |

Acceleration experiments go back a long way. In 1939, for example, Gauer and Ruff exposed 11 human subjects to 11 g for 3 min in the transverse, front-to-back orientation, or supine position, without reaching a tolerance limit, indicating that theoretical g-time exposures for both orbital and escape velocities could be endured. They cite Burlen's 1937 experiment, in which a human subject was

exposed to 17 g for 4 min in chest-to-back transverse acceleration on a human centrifuge.

Ballinger in 1952 subjected human volunteers to g-time configurations more than sufficient for attaining theoretical escape velocity. A human centrifuge of 25-ft radius was used to apply transverse acceleration from front to back. Subjects were fully supine in the first series, and with their knees elevated 20 deg, and trunk and head elevated to provide an eye to heart distance in the vertical plane of 7 in. in second series. All seven subjects complained of severe substernal pain and shortness of breath during 2 min and 40 sec of exposure to 8 g in the fully supine position. The semirecumbent position with knees and trunk slightly elevated diminished discomfort to an acceptable level at 8 g and made it possible for two out of three subjects to tolerate 10 g for 2 min and 6 sec.

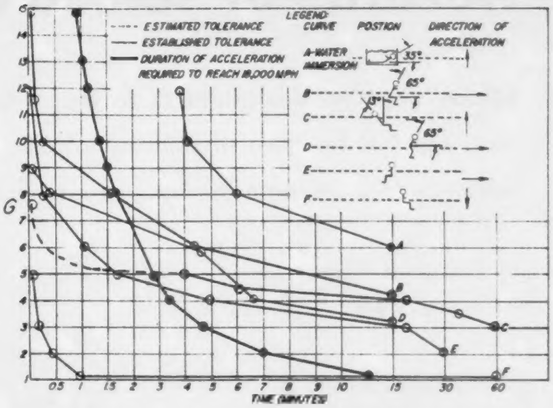
In 1955, Preston-Thomas and Edelberg, using the same centrifuge, positioned subjects on a litter that elevated the back and head 15 deg from horizontal and the knees at a 60-deg angle for acceleration in the transverse front to back direction. Capability of subjects to exercise manual guidance control was evaluated by a wrist joy-stick registering apparent vertical and horizontal components through potentiometer linkage to corresponding galvanometer dials. An oscillator with 0.083 cps output was used to produce asynchronous, spontaneous deviations in the pointers of the two galvanometer dials. Effectiveness of corrective actions taken by the subject was evaluated from oscillograph traces during g-time acceleration patterns simulating three-stage rocket accelerations with peaks respectively of 8, 5.8, and 5.8 g experienced within a 6-min exposure. It was determined that, under these conditions, 9 subjects were capable of manual control with a small loss of accuracy.

## Front-to-Back Acceleration

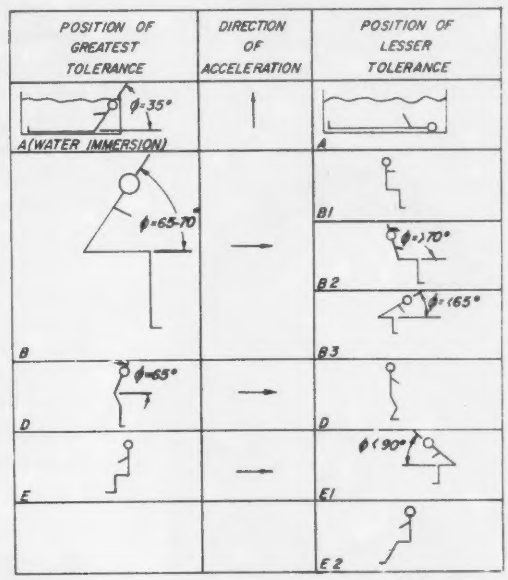
Bondurant and Clarke in 1958 reported on transverse, front-to-back accelerations of human volunteers on the same centrifuge. Rates of onset varied from 0.1 to 8 g per sec, building up to peaks of 8, 10, or 12 g. After each peak, deceleration to 1.5 g was effected in 20 to 35 sec. The succeeding acceleration was begun immediately. Each experiment consisted of successive accelerations to three instantaneous peaks of 8, 10, or 12 g. The rate of increase of acceleration that would attain more than 8000 meters per sec at peak acceleration for each stage, not counting 15–25 per cent excess acceleration because the centrifuge could not be stopped abruptly, was applied for each of three successive peaks during a run.

In the series of three (CONTINUED ON PAGE 98)

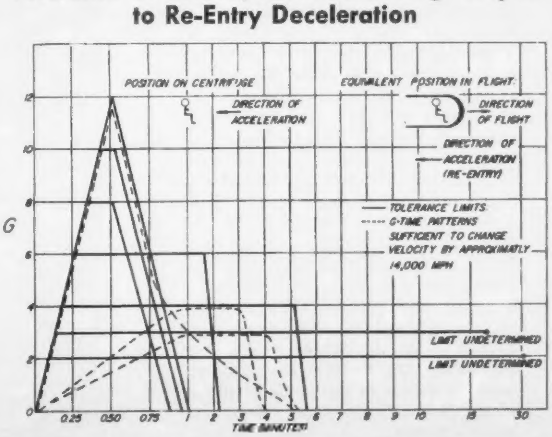
**Duration of Tolerance to Acceleration**




**Position Variations Decreasing Tolerance to Acceleration**




**Tolerance of Seated, Forward-Facing Subject to Re-Entry Deceleration**



# Hazards of sealed cabins

**Space capsule designers face the monumental task of protecting man against his own physiological and psychological weaknesses, a destructive environment, and even the equipment they give him**

*By Eugene B. Konecci*

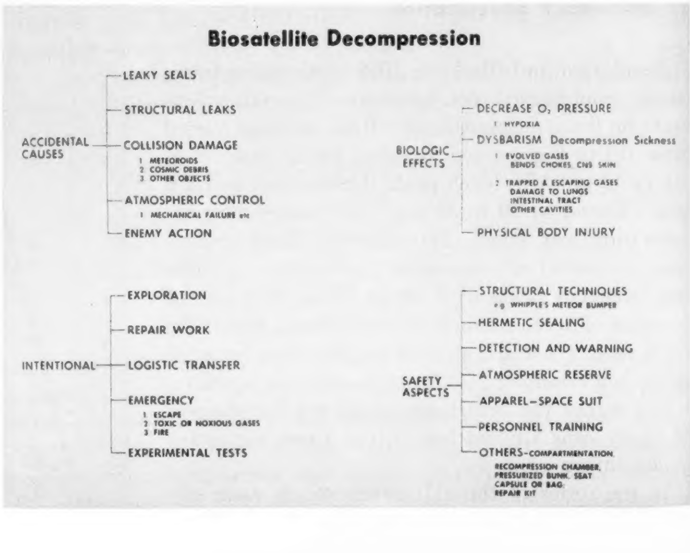
DOUGLAS AIRCRAFT CO., TULSA, OKLA.

JUST as the problems and risks associated with man in space vary with the duration of flight, so, too, do the hazards involved in the use of sealed cabins on such flights. Whatever the flight duration, however—be it a satellite flight lasting no more than a day, a lunar exploration mission taking 100 days, or a voyage to Mars or Venus which may take as much as 1000 days—every sealed cabin system will be exposed to certain physical conditions which may endanger its occupants.

These conditions are many, the more obvious among them being high acceleration, weightlessness, temperature and atmosphere changes, radiation, and collisions with meteoroids which might result in decompression. A look at each will help inform us of the hazards man will face in space flights.

Laboratory experiments indicate that a man in a semisupine position can withstand the acceleration forces expected from present three-stage rocket systems of the type which will in all probability be used to put the first men in space. Soviet data on Laika also reveal only the expected increases in heart rate and respiratory movements, indicating that the dog's breathing became more difficult, shallower, and more frequent with increased acceleration. The Russians conclude that the physiological changes observed during

Eugene B. Konecci is head of the human factors group at Douglas' Tulsa facility. After three years of military service in WW II, he received both bachelor (biology and chemistry) and doctoral (physiology) degrees while attending Clemson College, Roosevelt Univ., Univ. of Chicago, Univ. of Berne in Switzerland, the Air Command and Staff School, and the Oak Ridge Institute of Nuclear Studies, his doctorate coming from Berne. From 1950 to 1957, when he joined Douglas, he served first as a research scientist and then as chief of the Physiology and Toxicology Branch at the AF School of Aviation Medicine. Dr. Konecci has authored over 50 papers in the fields of physiology, radiobiology, flight safety, and human factors.



launch and ascent were due to acceleration, noise, and vibration.

Present indications are that noise levels inside the sealed cabin can be kept below critical levels.

After a satellite gets into orbit, the centrifugal forces acting upon it are balanced by the earth's attraction, resulting in a state of weightlessness. Aircraft flying a Keplerian trajectory have achieved zero or near-zero periods for only 30 to 40 sec, but even in such short periods about one-third of the subjects experienced nausea, vomiting, or vertigo to the point of incapacity. Many of the subjects who apparently were not affected in this manner suffered some odd effects, including one known as the "oculoagravic illusion," in which objects are seen at a higher level than they really are.

Some investigators believe the effects of the 30 to 40 sec of zero-g thus far achieved are due to changes in acceleration during the ballistic-arc maneuver of the aircraft, rather than to actual weightlessness, since Laika apparently exhibited no abnormal physiological reactions to about one week of weightlessness.

Psychophysiological adaptation may reduce the effects of weightlessness during orbital flight. However, prolongation of the zero-g condition may also effect the circulatory, nervous, and digestive systems, so that on re-entry, with severe deceleration, increased temperature, and the return of other multiple stimuli, there is no telling at this time what the effect would be on a man.

## Artificial Gravity as a Solution

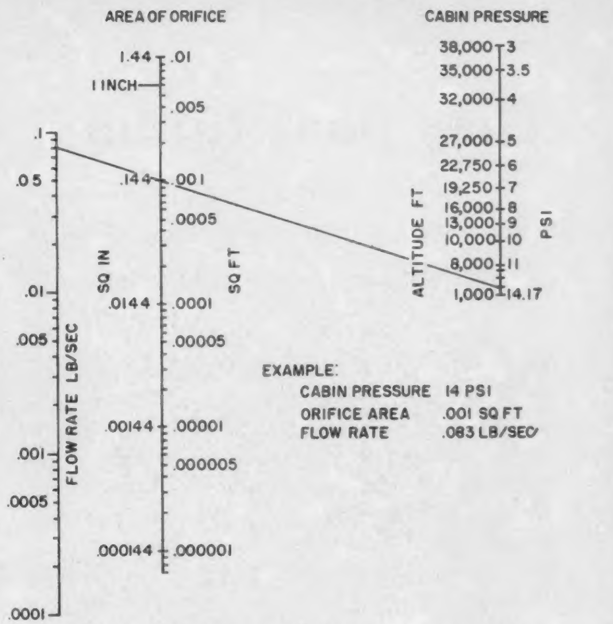
If weightlessness proves a problem in space, an engineering solution lies in creation of an artificial gravity condition in the crew compartment of the vehicle.

To remain alive in space, man will require an artificial environment defined by his physiology. Existing equipment and techniques indicate conventional means can be utilized to supply man with the oxygen, food, and water he needs to survive on his journey, with chemicals such as lithium hydroxide used to control carbon dioxide and humidity for trips lasting from 1 to 20 days. For longer journeys, conservation of materials by conversion and recycling may be necessary.

Carbon dioxide in particular poses a ticklish problem. It is a respiratory product which becomes a toxicant: 1 to 2 per cent $CO_2$ causes noticeable increases in breathing; 5 to 10 per cent results in panting, marked respiratory distress, and fatigue; and more than 10 per cent causes stupefaction, acts as a narcotic and finally causes death.

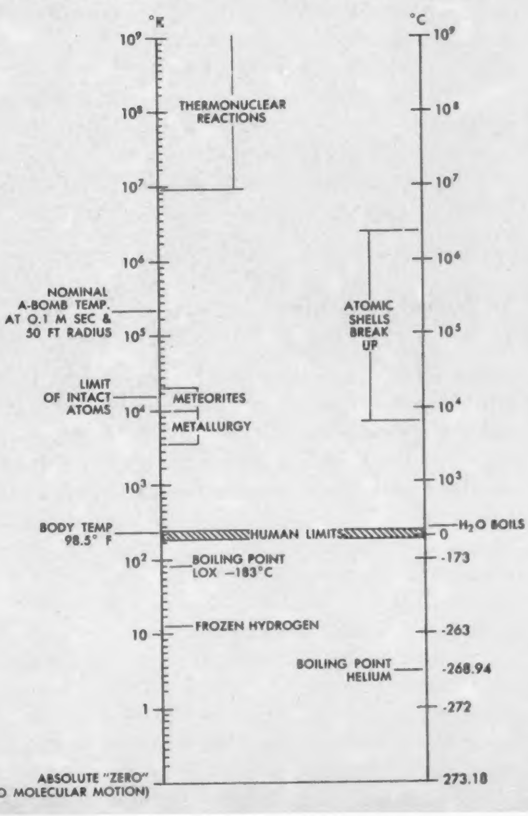
On long-duration flights, we will have to control other toxic substances lib- (CONTINUED ON PAGE 48)

**Flow Rate Nomogram**




Note: Cabin temperature of 70 F, orifice coefficient 1.0

**Temperature Spectrum Showing Human Limits**



# They float through the air

## Aero Medical Lab weightlessness experiments in C-131B transport permit human subjects to maneuver in zero-g state for 12–15 sec

DAYTON, OHIO—Use in recent months of a Convair C-131B transport in experiments designed to study the effects of short periods of zero gravity on human performance and behavior has for the first time permitted human subjects to float freely, without restraints of any kind, for weightless periods lasting from 12 to 15 sec.

These experiments, carried out by the AF Aero Medical Laboratory, Wright Air Development Center, Wright-Patterson AFB, Ohio, under the direction of AF Capt. Edward L. Brown of the crew stations research section of the Lab's engineering psychology branch, have made it possible to perform a number of interesting experiments which could not be conducted in the fighter-type aircraft normally used for such research. The C-131B provides a space a little over 6 ft high, 10 ft wide, and about 25 ft long which has been padded and is completely open, allowing the experimental study of such problems as human orientation and movement under zero-g conditions, and also permitting a number of experiments to be performed simultaneously.

### "Individual Propulsion"

One of the more interesting experiments deals with what might be called "individual propulsion" under weightless conditions. With a little practice, Capt. Brown says, a subject can learn to maneuver about in the cabin area as though it were filled with water. While the swimming motions used are not so immediately effective as they would be in water, the motions appear to be useful in moving from one place to another and in causing the body to change direction and acceleration.

It is also possible to tumble over and over in the cabin during the zero-g period. This is accomplished in a manner similar to rolling over under water, Capt. Brown notes, with the knees tucked in under the chin and the arms thrust outward and rotated vigorously. With correct timing, it is possible to start the body rotating and obtain several revolutions before the end of the weightless period. All subjects who have performed the maneuver report extreme disorientation, sometimes bordering on a severe case of vertigo, after a few revolutions.

Another interesting maneuver suggests how future space men may get from one place to another in their vehicles. The subject starts at the extreme aft portion of the cabin and, when the aircraft achieves zero gravity, floats up to a point about halfway up the back wall and then pushes gently against it. He then floats forward and, if the maneuver has been performed correctly, can float the entire length of the open area.

### Manipulative Tests

Experiments are also being conducted to note any decreases in performance of manipulative tasks due to zero gravity, utilizing a special test apparatus which shows the speed and accuracy of operation of various kinds of switches and levers. Thus far, it appears that no special provision for operation of such equipment will be necessary, since subjects without exception have been able to adjust to the zero-g condition in a matter of a few seconds if they had a solid position from which to work. A normal seat with a tight safety belt has proved adequate in this respect.

Thus far, a number of subjects have gone through the "floating" experiments, including several women and even a reporter from one of the Dayton papers, without ill effects. The studies will continue until they have explored all aspects of human behavior and performance under zero-g conditions. —I. H.

**Capt. Edward L. Brown, chief of the crew stations research section of the AF Aero Medical Lab, demonstrates free floating during zero-g period in Convair C-131B transport. Padded area 25 ft long, 10 ft wide, and 6 ft high is available for experiments.**

# Year II of the space age

**NASA and ARPA each plan at least a dozen satellite or space probe launchings this year. . .Man-in-Space program also to be stepped up**

OUT OF the confusion arising from the various "authoritative reports," rumors, and gossip concerning U.S. space plans for 1959 has come the outlines of what appears to be a well-planned, well-coordinated program which will see at least one major satellite or space probe launching attempt on each Coast during 1959, as well as a stepping-up of the Man-in-Space effort.

At the moment, Year II of the Space Age shapes up like this:

NASA—The nation's civilian space agency already has on order or is dickering for about 30 to 35 booster vehicles. Actual figures look something like this: NASA has four Juno II's on order, with negotiations well advanced for eight more. Discussions have been going on for some time with the Army for procurement of eight or ten Redstones and with the Air Force for a number of Atlas ICBM's to support the Man-in-Space program. At least two Thor-Able vehicles are scheduled for early delivery, with negotiations now going on for several more. And, finally, the four remaining Vanguard vehicles will be launched some time during the year.

Not all of these 30 to 35 vehicles will be used, or even delivered, during 1959. However, NASA Deputy Administrator Hugh Dryden's prediction of eight to twelve NASA firings in calendar 1959 is regarded as a deliberately cautious statement, and can be taken as representing a minimum.

Apparently set for early launching are: A Juno II carrying the NASA 100-ft aluminized plastic balloon; two Thor-Ables designed to put payloads in huge orbits with apogees of 40,000 to 100,000 miles; a space radiation probe carrying a 50-lb payload to obtain data about the Van Allen radiation band; and a low-orbit Juno II carrying cosmic ray instrumentation and other experiments.

Preceding these, and scheduled for last month, was the second Army moon shot, utilizing the same Juno II vehicle as that used in the unsuccessful Dec. 6 shot and a similar cone-shaped Pioneer payload. The new payload, however, was expected to be modified to include lunar photography equipment, as well as radiation counters, possibly adding some weight to the 13 lb sent 70,000 miles into space in the Dec. 6 experiment. In February, the first of the four remaining Vanguards will be fired, this time carrying a weather reconnaissance payload.

NASA's firings are expected to center on Cape Canaveral, although its Wallops Island, Va., facility may also be used for some launchings. A good deal of NASA's efforts this year will center on tests leading to manned orbital flight.

ARPA—Major effort here will be centered on the Discoverer satellite program, regarded as being largely a cover for the Sentry reconnaissance satellite program. ARPA Chief Roy Johnson has already said there will be "at least a dozen" attempts in the Discoverer program, with firings scheduled about once a month from the new Pacific Missile Range. The program will utilize Thor-Hustler vehicles initially, with Atlas ICBM's plus a high-energy second stage (probably incorporating the new Pratt & Whitney engine) used as the program progresses.

While the bulk of the Discoverer experiments will support the Sentry program, centering on such things as spatial orientation, temperature control, photographic scanning techniques, and controlled recovery, there is a good chance that animal subjects will be going along for the ride by late spring.

As Roy Johnson noted at the ARS Annual Meeting in New York last November, ARPA, charged with cognizance over the nation's military space effort, is focusing its attention on the development of communication, navigation, early warning, and tactical cloud cover satellites.

This year will also see construction of the first space capsule to be used in putting man in space, although the first actual launches are unlikely before 1960, if then. Long before that, however, North American test pilot Scott Crossfield will have taken the NAA X-15 rocket-powered aircraft aloft for its first tests.

Plans for the launching of Atlas ICBMs carrying 5-ton payloads, additional moon probes, and possibly even probes to Mars, Venus, and beyond, and the first major attempts at satellite recovery during 1959 indicate the U.S. has come a long way in the past year.

Lunik I gives us some notion of Russian plans for space exploration.

Certainly at this moment 1959 measures up as a momentous year in the history of astronautics.

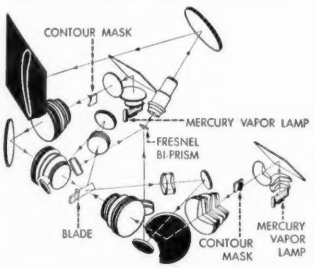
# Kodak reports on:

**a large optical device . . . how much better x-ray film is getting . . . a device with enormous potentialities for inventiveness**

## For blades (also vanes and buckets)

Many mathematical minds, mighty mathematical machines, and much aerodynamical experimentation have created the shape of a blade from a jet engine. Violation of the plan to the extent of a few thousandths of an inch in a single cross-section of a single blade sucks at efficiency like a little leech. And there are so many blades in a single compressor or turbine that the total number of them made in the brief span of air-breathing non-reciprocating history must compare with all the wooden spokes in all the wagon wheels of all the supply trains in all armies since Alexander the Great. Tolerances on wooden spokes have always been broad.

Therefore we have been busy lately building a large optical device. It works as follows:




Recently the two mercury lamps were turned on and the first cross-section of the first blade was seen in magnification against its tolerance envelope scribed on the screen. Inspection from now on should go well.

*The device has been named* Kodak Section-Profile Projector. *It is enough to restore faith in the future of geometrical optics. Inquiries go to Eastman Kodak Company, Special Products Division, Rochester 4, N. Y.*

## AA—KK

X-ray film is getting better.

Our fastest kind used to be *Kodak Industrial X-ray Film, Type K.* Now we call it *Type KK.* The speed has gone up 50%. A 72-hour exposure becomes a 48-hour exposure. Time is money. So they say. Same principle applies to uranium fuel elements. (To $Cs^{137}$ gamma rays, ¾″ of uranium looks like 4″ of steel.) *Type KK* is a bit grainier than *Type K.* But it has higher contrast. The gain outweighs the loss. Up goes "radiographic sensitivity."* Radiographers can spot smaller voids.

*Kodak Industrial X-ray Film, Type AA* beats *KK* seven ways to Sunday for "radiographic sensitivity." It's some slower, though. As *Type A,* it used to be a lot slower. That was a little over a year ago. It was then the most widely used x-ray film in industry. Now it's more so. That sounds like tautology. Nevertheless, it makes us happy. With the higher speed, inherent contrast has gone up, not down. Grain's the same. This is remarkable.

*Don't trip. "Sensitivity" doesn't mean "speed" here.

They can just reduce exposure time. Even for thinner specimens time is money. So it is said. Or they can cover more area at a single exposure. That's another way to save time. Or they can get their usual density with shorter processing. This likewise saves time.

Or they can take the same time and get more film density.

Or they can get through the specimen with less penetrating radiation.

*Kodak Industrial X-ray Film, Type M* is for maximum detail and no rush, or else light specimens. *Kodak Industrial X-ray Film, Type F* goes with calcium tungstate screens. Their fluorescence in the visible intensifies the exposure. In a pinch that's sometimes all right.

*Don't worry. You'd get the hang of it if you had to. Yes, even the radiography of plutonium hardware, where you're recording both endogenous and exogenous radiation. We'd give you what advice we could (but very little about plutonium). You'd write Eastman Kodak Company, X-ray Division, Rochester 4, N. Y.*

*We also have some freshly minted advice on silver-sensitized goods for dosimetry, including a bibliography. If* that's *all you want, write Eastman Kodak Company, Special Sensitized Products Division, Rochester 4, N. Y. Ask for the new pamphlet, "Radiation Monitoring with Kodak Personal Monitoring Films." It's useful for processing techniques, if nothing else.*

## They transduce

We make *Kodak Ektron Detectors* like these for transducing a visible or infrared pattern into electrical terms. The darker material is photoconductive lead sulfide or lead selenide; the electrodes (actually evaporated gold) appear grey here. Since we can lay down the photosensitive material in any configuration, enormous potentialities for inventiveness present themselves. Whether you seize them is entirely up to you. We offer a pamphlet, "Kodak Ektron Detectors." You get it by writing Eastman Kodak Company, Special Products Division, Rochester 4, N. Y. It describes what spectral sensitivities and time constants can be selected and very, very briefly summarizes the circuitry considerations—a little rough, perhaps, for persons with casual interest in this sort of thing. It does tell enough to place an order for breadboarding purposes or a request for quotation.

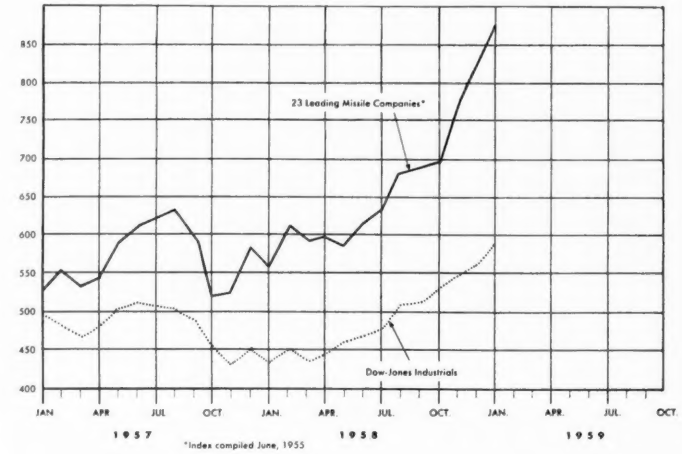
**This is another advertisement where Eastman Kodak Company probes at random for mutual interests and occasionally a little revenue from those whose work has something to do with science**

Kodak
TRADE MARK

# Missile market

**BY ROBERT H. KENMORE, Financial Editor**

THE MARKET AT A GLANCE




| | Jan. 1959 | Dec. 1958 | % Change | Jan. 1958 | % Change |
|---|---|---|---|---|---|
| Dow-Jones Industrials | 584 | 560 | +4.3 | 439 | +33.0 |
| Missile Index | 881 | 838 | +5.1 | 563 | +56.5 |

BOTH the Dow-Jones Industrials and the Missile Index finished the year with a final upward thrust and closed at new all-time highs. The past year was indeed a profitable one for investors. But what about 1959? For the economy as a whole, 1959 will see a continuation of the recovery from 1958's midyear recession, but no runaway boom is envisioned.

Will the stock market boom, then run out of steam, or will it continue at the dizzy pace of last year's fourth quarter? The answer to that question does not lie in an examination of the classic determinants of stock prices—earnings and dividends—but rather on a realistic appreciation of today's methods of valuation.

Many a Wall Street professional is already muttering that prices are too high, that investors are paying for 1965 earnings and dividends, and that another 1929 crash cannot be far behind such "unrealistic" valuations as 40 times earnings and 2 per cent yields—when bonds are yielding $4^1/_2$ per cent. The truth of the matter is that "realistic" prices are those which investors are willing to pay for common stocks, and it is the professionals who must re-evaluate their standard methods of appraisal.

It is true that the market will sometimes overreach itself, and a correction becomes necessary, but the basic long-term trend is what matters, and the trend continues upward. Today's market is not one of speculators and uninformed investors, and built on credit. Rather, it is buoyed up by a continuing influx of new capital from an ever-growing group of institutional investors and a broadening mass of new individual investors whose disposable income has never been so high, and who are much more sophisticated about money management than their fathers ever were.

On the other hand, new common stock issues to satisfy this hunger for investment are not forthcoming, and funds are therefore being funneled into already existing media for participation. The result is inflation, and not the type of inflation commonly cited as the reason why people buy common stocks—the gradual erosion of the dollar against which people wish to protect themselves—but a dramatic supply-demand inflation in the value of stocks themselves. When Chilean copper mines are struck for an extended period of time, the price of copper shoots up. When the Brazilian coffee crop is damaged by blight, you pay more for coffee. In the same manner, when more new money is coming into the stock market and fewer new issues are being sold, stock prices are forced up.

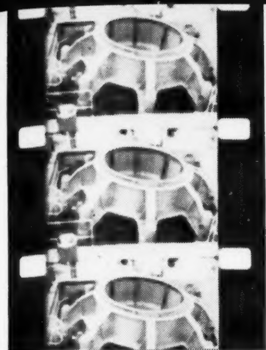
What changes, then, are not earnings and dividends (although these are also in a rising trend again, compounding the upward movement of securities), but rather such yardsticks of valuation as the price-earnings ratio and acceptable yields. Like all markets, this one will eventually run ahead of itself, just as the 1946 market did, but that time is not yet at hand. For the foreseeable future, the influx of new money will not abate, nor will corporations increase their financing plans to a significant degree to satisfy this demand. The latest round of corporate expansion gave companies all the production capacity they needed. However, even where additional financing is required, business is now in a position to issue additional debt, which is much cheaper under present tax laws.

All the above does not mean the investor can now throw all caution to the wind and plunge into an orgy of indiscriminate buying. On the contrary, selectivity is more important than ever, and the investor must insist on getting as much growth as possible for his new, higher price-earnings valuations.

In this respect, investors in the missile industry are fortunate, for growth is the keynote of companies in this field. To establish some basis for investing in this growth, however, the following rule-of-thumb may be useful. For companies that demonstrate a yearly growth rate of 10 per cent (per-share earnings expected to double in seven years) a price-earnings ratio of 12–20 times on present earnings seems justified. Whether it is 12 or 20 times will depend on such factors as how much of these earnings are paid out in dividends, whether adequate provisions are being made for research and development, general market psychology about the issue, quality and depth of management, and many other tangible and intangible factors.

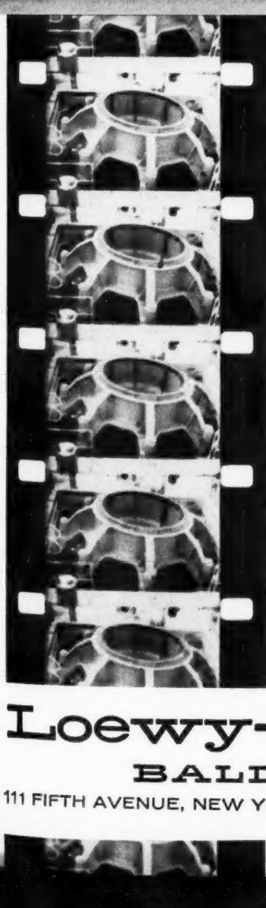
In addition, this yardstick alone

(CONTINUED ON PAGE 114)



"Shaker" pitching

"Shaker" rolling



# "Shaker"—Loewy's giant rocking horse—paves way for ballistic missile firing at sea

The giant ship motion simulator called "Shaker" has come to life. Designed and built by Loewy-Hydropress under prime contract with the U.S. Navy for its Fleet Ballistic Missile Program, the 40-ft.-tall rocking horse moves up and down, fore, aft and athwart under the electronic fingertips of a distant operator in a thick-walled concrete blockhouse.

"Berthed" at Cape Canaveral not more than 800 feet from the beach and nested in a 47-ft.-deep pit, "Shaker" performs all the important movements of a seagoing vessel. Sliding up and down, she imitates the vertical heave motion. Tilting port and starboard, she acts out rolling. Rocking forward and backward, she duplicates pitching. An intricate mechanism of giant gyrating joints makes these rock 'n' roll moves and their innumerable combinations possible. By proper setting, the typical behavior of an oceangoing vessel in seas ranging from calm to stormy can be recreated precisely by "Shaker."

Polaris, the Navy's Fleet Ballistic Missile, will soon be tested on "Shaker."

For creative engineering and design, research and development in your defense and industrial contracts, direct your inquiries to us at Dept. G-2.

**Loewy-Hydropress Division**

**BALDWIN · LIMA · HAMILTON**

111 FIFTH AVENUE, NEW YORK 3, N.Y. Rolling mills • Hydraulic machinery • Industrial engineering

## Hazards of Sealed Cabins

(CONTINUED FROM PAGE 41)

erated into the cabin atmosphere—carbon monoxide from smoking, overheating of equipment and fires; ammonia from urine; methane and hydrogen formed by bacteria in the bowels and introduced into the cabin as flatus; evaporation of sweat and glandular excretions of the skin; and indole, skatole, $H_2S$, phenol, and various amines from the feces.

If high-oxygen-partial pressures in the sealed cabin are contemplated to save the weight of oxygen containers, the fire hazard would increase. It is possible that, for short-duration flights, and with proper safety precautions and training, this procedure would work. However, at oxygen pressures above 425 mm of Hg, symptoms of oxygen poisoning will appear after several days' exposure.

### A Primary Danger

One of the primary dangers facing all prospective astronauts is the loss of cabin pressure and, consequently, life-sustaining oxygen. Any opening in the cabin will result in loss of the precious gas. Hence, hermetic sealing of the space cabin is essential. The causes, biological effects, and safety aspects of decompression in space are summarized in the chart on page 40. Hypoxia is the real danger in space decompression. Slow, rather than explosive (less than 1 sec), decompressions are expected. It should be noted that a small, 200-cu ft cabin would require a hole of about 50 sq in. to decompress through a cabin pressure of 50,000 ft (less than 2 psi) in 1 sec.

Studies by Beisher show marked dehydration due to vaporization and evaporation of body fluids at the surfaces occurring in hypoxia-resistant frogs and worms exposed to about 5 mm Hg (110,000 ft) pressure for about 1 hr. If decompression did occur in a spaceship, it would be possible by means of certain safety features to offset the effects until the leak was located and sealed.

Recompression following decompression must not be explosive—that is, raised in a few milliseconds. Recent animal experiments of Kolder in Vienna show a high death rate due to explosive recompression following 1- to 2-sec decompression to low atmospheric pressure.

Space flight entails the probability of collisions with meteoroids. Whipple, Grimminger, and others have made calculations and predictions of the probabilities of meteoritic hits and penetrations. Additional satellite data will be required, however, before the true danger from meteoroids can be determined.

Decompression as a result of meteoritic penetration will be determined by cabin wall thickness, frequency of hits, and time of exposure. In general, the expected meteoroid hole will be very small. However, to prevent loss of oxygen, these leaks will have to be rapidly detected and sealed. A 0.005 sq in. hole, with a cabin pressure of 14.7 psi, will leak at about 0.003 lb/sec, or 10.8 lb/hr, which means a 120-day oxygen supply for one man would be lost in just one day. The flow-rate nomogram on page 41 can be used to determine flow rates for various hole sizes at different cabin pressures, assuming an orifice coefficient of 1.0.

However, leaks through structures and seals may prove to be more important than meteoroid penetrations. If, for some reason, hermetic sealing is not possible in the first space cabins, leak rates will have to be precisely determined or calculated so that adequate oxygen reserves are carried on board.

An unexpected danger to manned space flight was discovered by our Explorer satellites. This is in the form of a radiation storm encountered about 600 miles from Earth. Whether this radiation is due to cosmic rays, solar X-rays, protons, or high-speed electrons has not yet been established. Its intensity at 600 miles has been estimated at 0.06 roentgen (r) per hour, which indicates that man would receive the maximum permissible (AEC) yearly dose of 15.6 r in about 10 days. Explorer IV measurements indicate about 2 r/hr at about 1380 miles above South America. The diagram on page 41 shows that a dose rate of 10 r/hr would probably be fatal to 100 per cent of the crew within 60 hr. In other words, they would have received a dose of 600 r.

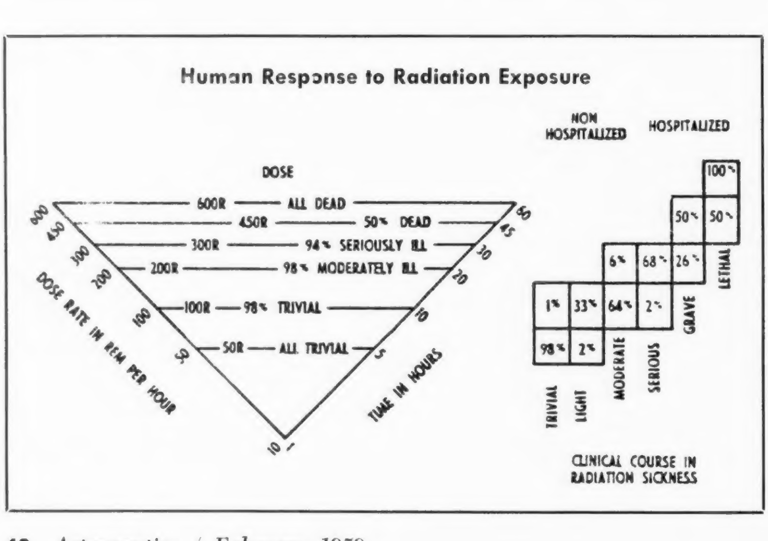
### Shielding

If the measured radiation is due to soft X-rays, the cabin could be shielded. However, in addition to weight, shielding may slow down primary cosmic nuclei and make them more dangerous. The primary particles have energies in the order of billions of electron volts, which can easily penetrate the sealed cabin and may knock out whole human cells without causing excessive damage. If mass shielding is interposed between man and the primary nuclei, however, the cosmic rays could be slowed to where they would hit more molecules in the body and cause extensive biological damage. This implies that improper amounts of shielding might prove catastrophic. Additional data will help determine the extent and nature of the radiation band. It may be possible to eliminate the need for a mass shield by rapid passage through the radiation field or through radiation-free polar routes, if they exist.

Medical evidence as to the ability of the human body to sustain instantaneous or short-term exposure to total body radiation appears to be reasonably clear. The chart shown at the left, which is based principally on a study by Gerstner, illustrates and summarizes the clinical picture. These data are based on nuclear accidents, effects on radiologists, Hiroshima and Nagasaki victims, and patients receiving radiation therapy. It appears reasonable that short-term exposures should be kept below 200 r to avoid serious clinical consequences.

Future space operations may require the use of nuclear power, and human crews may have to be exposed

**Human Response to Radiation Exposure**



ely
de-
on

ned
our
the
ved
her
ys,
ed
ed.
en
ber
ld
ble
out
nts
80
ia-
ose
be
in
ld

to
be
to
ri-
em
ar-
of
an
nd
lls
If
en
w-
ed
le-
ve
at
ht
ta
a-
be
a
gh
a-

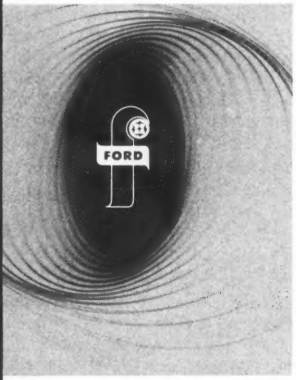
ty
n-
al
n-
ne
a
n-
se
s,
d
v-
rs
es
id

e-
d
ed

# MILITARY SYSTEMS CAPABILITIES

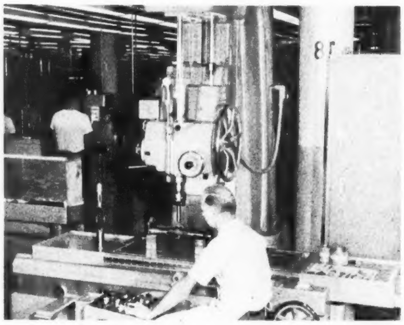
FORD INSTRUMENT CO.
DIVISION OF SPERRY-RAND CORPORATION

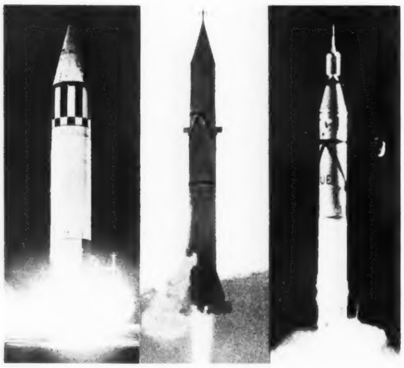
# Ford Instrument aero-space capabilities




***Wide experience in these vital new missile and aero systems equips Ford Instrument for major responsibility in the most advanced fields***

Ford Instrument Co., Division of Sperry Rand Corporation, offers defense agencies a background of *44 years' continuous experience* in initiation, development and quantity production of military equipment and weapons control systems. Today, in the dawning space age, Ford Instrument experience, as outlined in the illustration opposite, already encompasses a wide variety of activities in the forefront of this field. Notable are inertial guidance and control systems for the U. S. Army Ballistic Missile Agency's REDSTONE and JUPITER missiles, developed with ABMA and manufactured by Ford Instrument; many guidance and control components on the Army's satellite-launching JUPITER C; navigational systems in wide operational use by the U. S. Air Force; and many highly advanced activities such as research into new types of inertial guidance systems for USAF's WADC Weapons Guidance Lab.





**DEVELOPMENT** – *Top photo.* Gyro for stable platform under test in development lab. Ford Instrument is also designing advanced inertial guidance systems incorporating new concepts.

**MANUFACTURING** – *Center photo.* This photograph shows machining of piece for JUPITER stable platform ... in one of Ford Instrument's many precision production shops.

**END USE** – Ford Instrument manufactures guidance and control systems used in JUPITER *(left)*, REDSTONE *(center)* and many similar components in JUPITER C *(right)*. Ford Instrument has worked closely with the U.S. Army on these ABMA-developed missiles. *(U.S. Army photos.)*

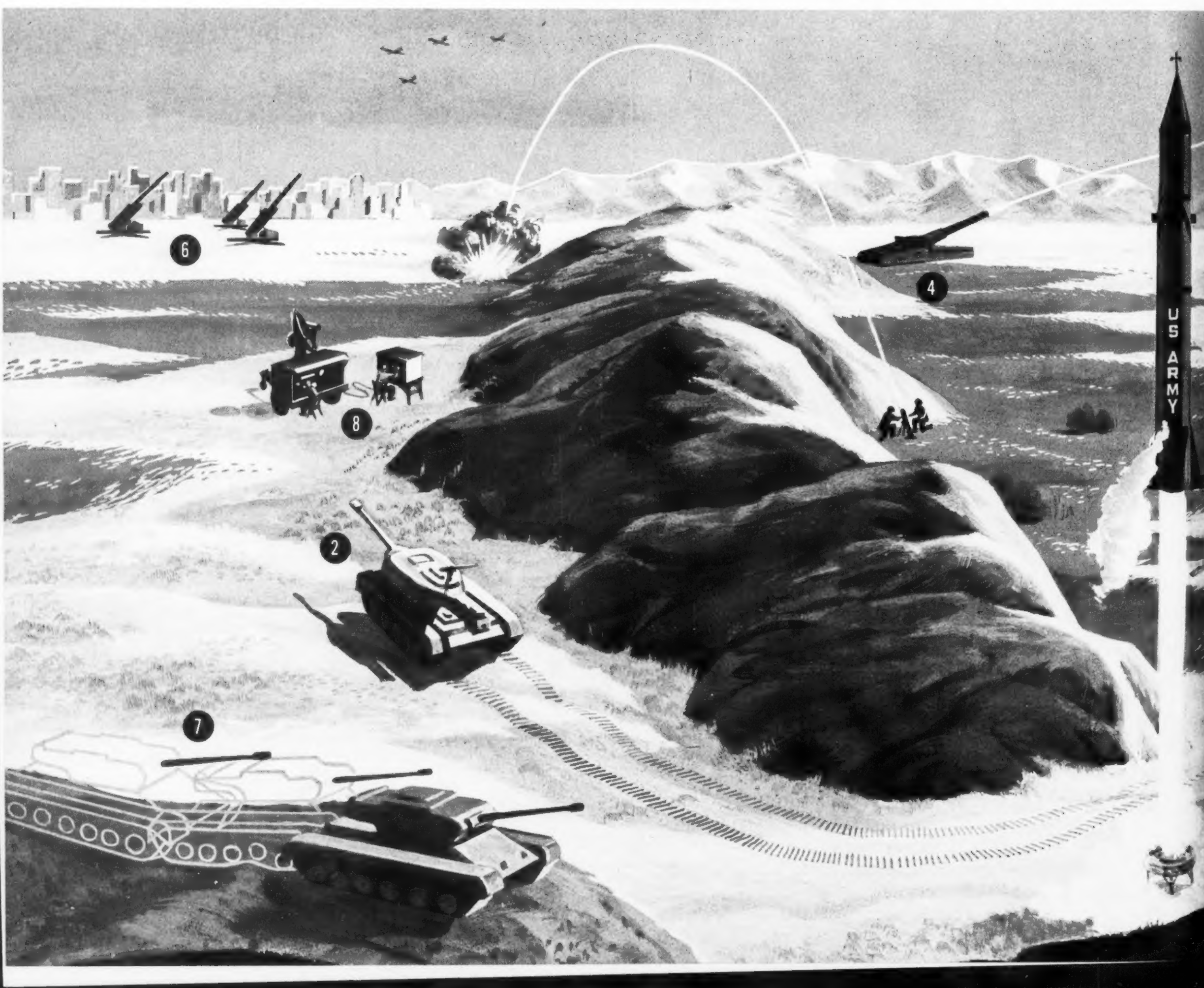

**Ford Instrument aero-space capabilities include:**

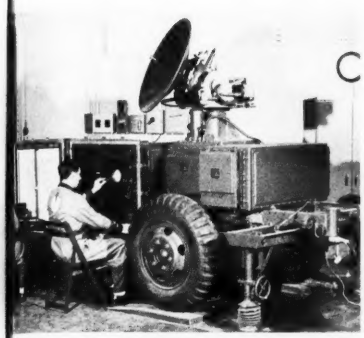
1. Inertial guidance and control systems
2. Nuclear power-plant designs for satellites
3. Guidance and control equipment for satellite-launching and space-exploratory vehicles
4. Prelaunch computers and ground support equipment
5. Missile firing range instrumentation
6. Reconnaissance systems for aircraft and space platforms
7. Automatic navigation and mission control systems
8. Traffic control equipment
9. Safety, fuzing and arming devices
10. Remote control systems for drones and platforms

# Ford Instrument ground systems capabilities

***New methods of attack on military problems require a wide range of engineering skills . . . mechanics, electronics, optics, computer technology***

New weapons and materiel are changing the techniques of ground warfare today as at no time in past history. The unique capabilities of Ford Instrument in automatic control and computer systems are being put to use in implementing and shaping new concepts of ground warfare. Some of these capabilities are shown in the artist's conception below. Notable Ford Instrument experience includes: Development of a system for control of aerial drones for combat surveillance and reconnaissance; development of a computer for vehicle navigation in trackless wastelands; and inertial guidance and control for the REDSTONE tactical ballistic missile.

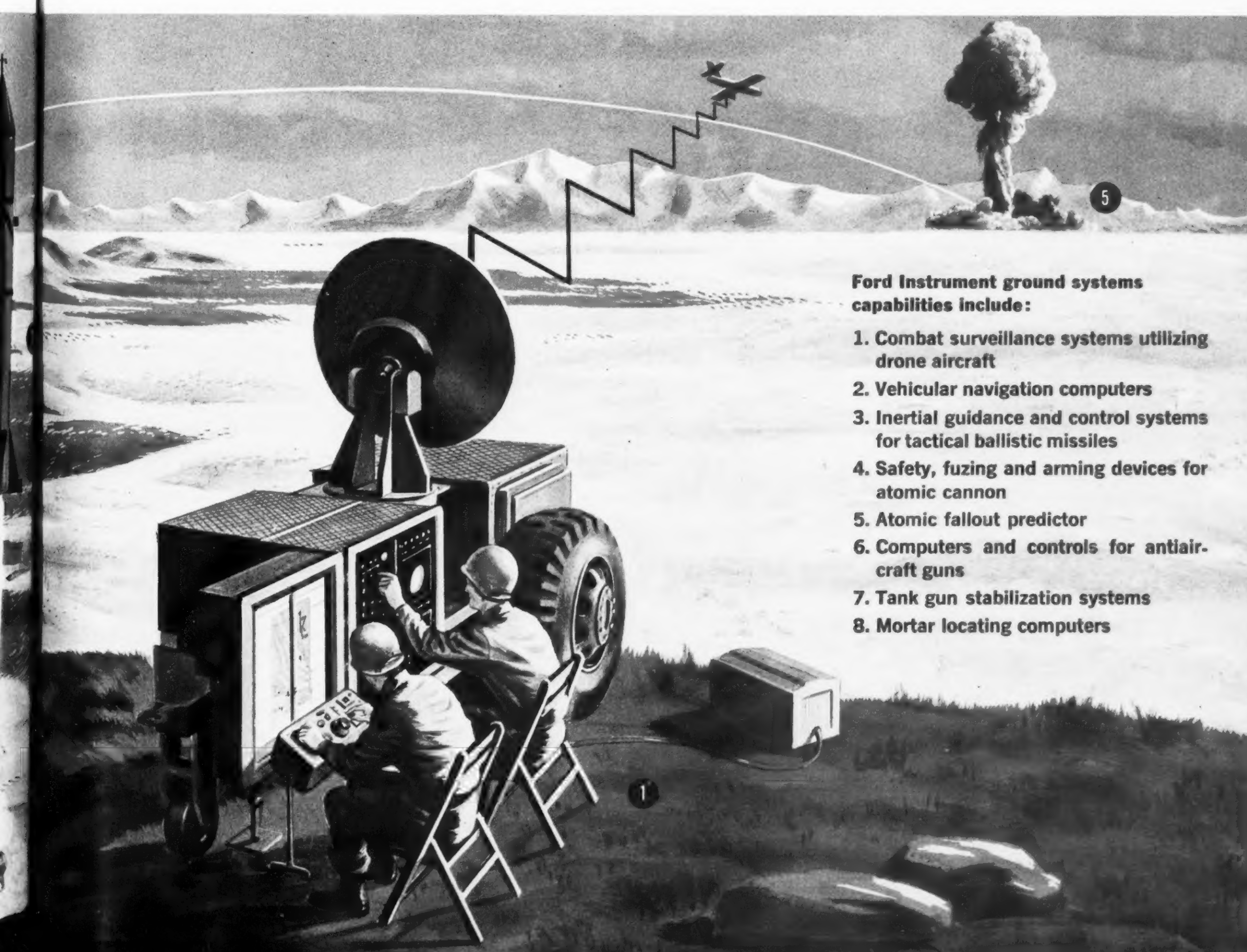




EVELOPMENT—Trailer for combat surveillance (drone control) system. Ford Instrument worked with U.S. Army Signal Corps on this system, comprised of radar, tracking, telemetering, computing, plotting and control equipment.

**MANUFACTURING**—A step in the manufacture of a precision computing cam. Ford Instrument has extensive facilities for precision machining, is widely experienced in both electronic and mechanical computer techniques.

**END USE**—U.S. Army atomic cannon shown at test firing. Ford Instrument developed and produced complex safety, fuzing and arming device for this weapon, is one of few companies with wide capabilities in warhead control work. *(U.S. Army photo.)*



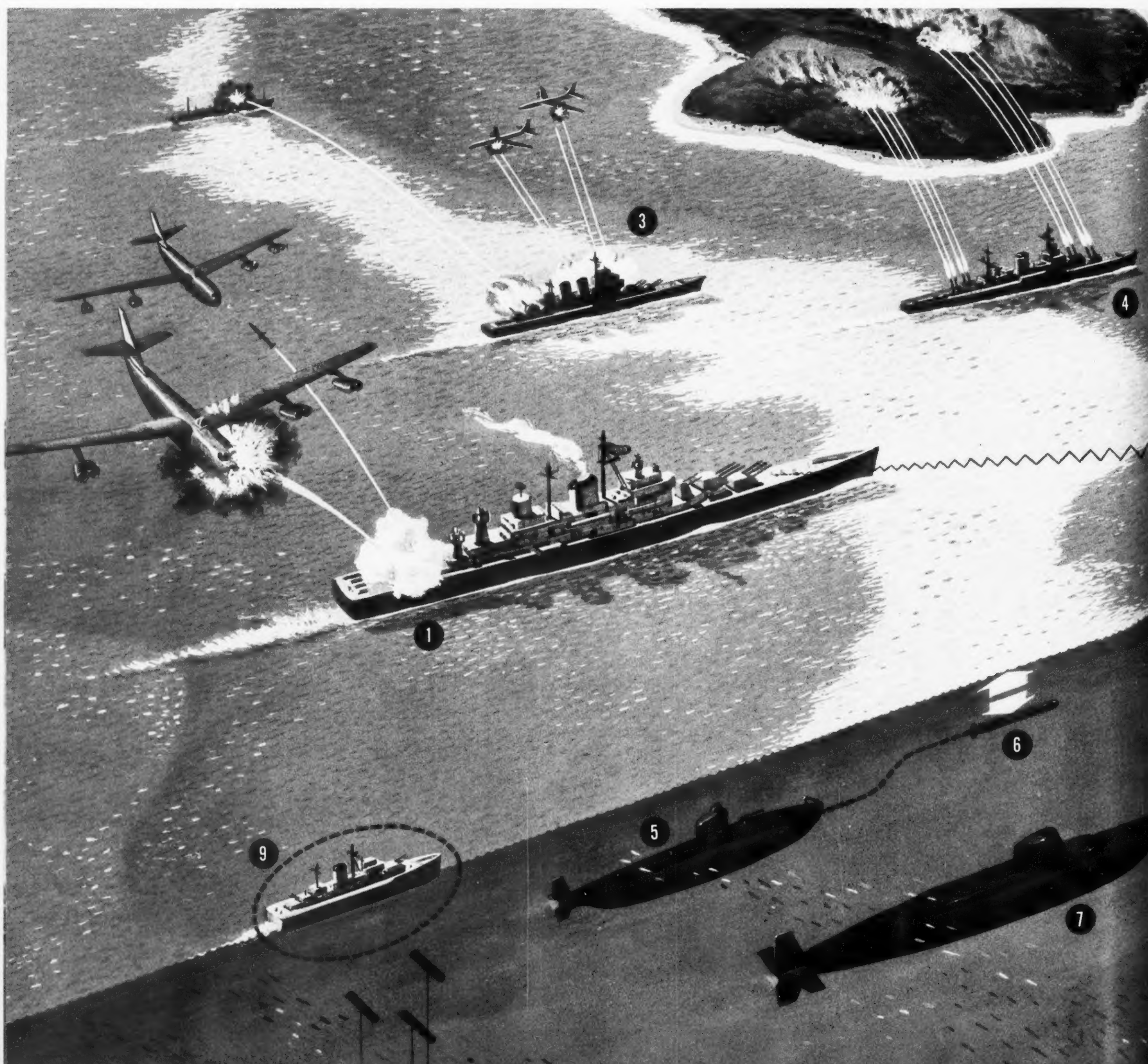

**Ford Instrument ground systems capabilities include:**

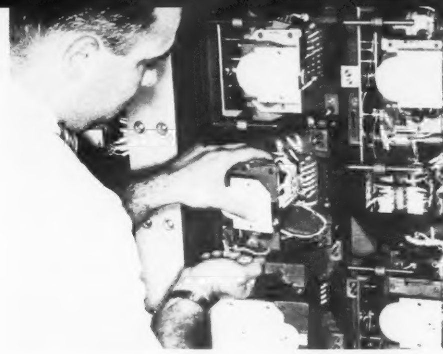
1. Combat surveillance systems utilizing drone aircraft
2. Vehicular navigation computers
3. Inertial guidance and control systems for tactical ballistic missiles
4. Safety, fuzing and arming devices for atomic cannon
5. Atomic fallout predictor
6. Computers and controls for antiaircraft guns
7. Tank gun stabilization systems
8. Mortar locating computers

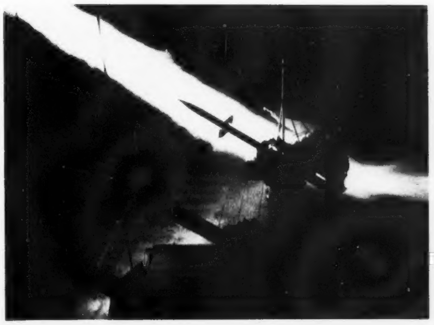
# Ford Instrument naval systems capabilities

***Ford Instrument has over four decades of experience in development and production of complex computer and control systems for U. S. Navy weapons***

Ford Instrument experience in naval systems encompasses complex equipment for all phases of naval warfare—surface, air-defense, and underwater. Ford Instrument's long history of working with the U. S. Navy began with manufacture of one of the earliest analog computers for solving fire control problems (Range Keeper Mk 1, *circa* 1915). Today, Ford Instrument's naval systems activities continue with development and production of such vital modern equipment as the launching and control order computers for the Navy TERRIER and TARTAR missiles, control rod drives and other instrumentation for atomic submarines, plus a wide variety of operational fire control equipment for naval guns and rockets. Some of these advanced naval capabilities are shown on the panorama below.



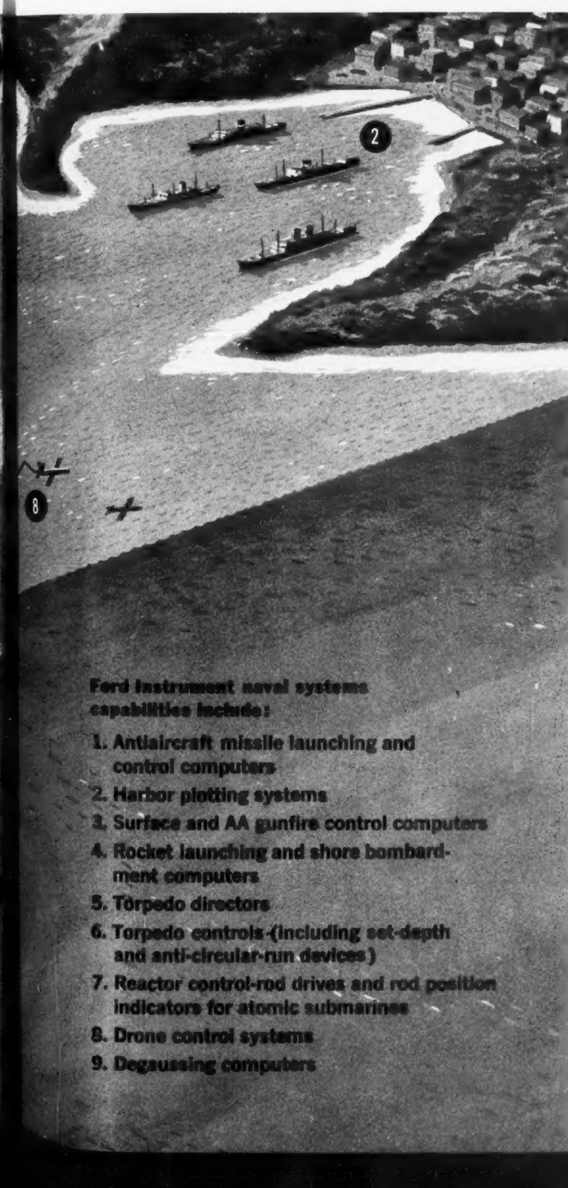


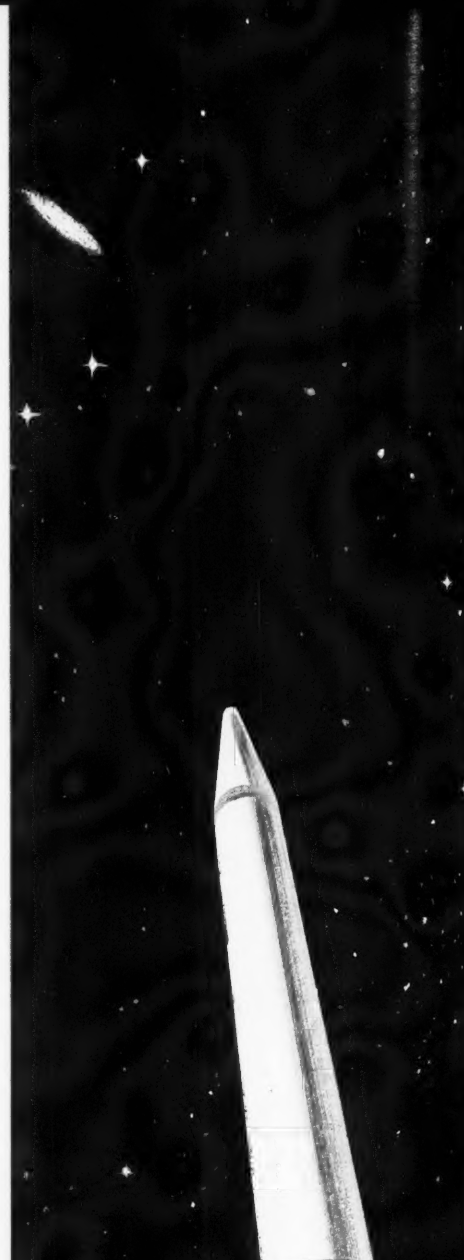


**DEVELOPMENT**—*Photo above.* Electronic section of the all-transistor computer developed to solve launching and control order problems for TARTAR missiles. Note ultra-compact modular construction which greatly facilitates maintenance.

**MANUFACTURING**—*Top photo.* A technician makes final check-out on Mk.47 AA and surface gunfire control computer before delivery to U.S. Navy. Ford Instrument is one of a few companies having thorough experience on *all* types of computers and control systems—electronic, electro-mechanical, mechanical, hydraulic.

**END USE**—*Left photo.* Night firing of U.S. Navy TERRIER missile. Ford Instrument is proud of its part in the production of the vital TERRIER-TARTAR weapons systems for fleet air-defense. *(U.S. Navy photo.)*





to radiation greater than 0.3 r/wk. Under such conditions, excessive exposure becomes part of the hazards of space flight, and may be accepted on a par with other risks. Operational necessity or an emergency may require exposure to excessive radiation intensities; if so, the calculated risks must be weighed against the objectives to be attained. Continued exposures at 0.3 r/wk is equivalent to about 15 r/yr, so that over a 30-year working period, a total dose of 450 r would be received. Such a dose would be lethal to about 50 per cent of the individuals affected, if obtained in a single, short-time exposure.

The consequences of chronic, lifetime, or sporadic exposure to radiation are not clear. There is evidence, however, that long-term damage can be assessed largely in terms of decreased lifespan. Increases in such specific diseases as leukemia are statistically less important than increases in death rates from all causes. Moreover, analysis and extrapolation of data on radiation damage from animals suggest that a reasonable, though uncertain, estimate of the extent of life shortening might be something like 7 yr per 1000 r for children, and less for adults.

## 91-g Deceleration at Hurricane Mesa

**Fast-action photo catches 6950-lb test vehicle traveling 940 mph at AF Hurricane Supersonic Research Site, Utah, smashing through masonite dams just before reaching peak braking force of 632,000 lb and a maximum point of deceleration of 91 g. Test was conducted by Coleman Engineering Co., Inc.**

#### Temperature Problem

What of the temperature problem? In the temperature spectrum on page 41, it will be noted that human limits are represented by a very narrow band. Man will be dependent on the sealed cabin for temperature and humidity control in this band. This control must affect the radiation exchange between the surface of the cabin and all bodies radiating on it. The background of space can be considered as a radiation sink with the temperature absolute zero. The surface covering of the outside of the space cabin will determine the radiation equilibrium temperature established with the two major radiation sources, the sun and the Earth.

The equilibrium temperature of a cabin in space will depend on the radiation emissivity and heat capacity of its surfaces and its flight path, which determines the duration of exposure to direct solar radiation and reflections from the Earth or a combination of both. The stripe painting and spinning techniques used for temperature control with the Explorer satellites look promising. However, it would not be desirable to spin a cabin at a high rate.

Man and the equipment in the cabin will be a constant source of heat. The average man will liberate 3000 kcal, or about 12,000 Btu per day. Excessive heat in the cabin will have to be transferred to radiant surfaces or disposed of in some other way. The vacuum and radiation in space may affect the surface coating of the cabin by peeling, blistering, or changing the color and completely disrupting thermal balance. Additional information is needed on this vital subject.

On re-entry, the air near the surface of the spaceship will be heated. This heating is due to compression near the stagnation points and friction in the boundary layer. It increases with the speed squared, and, at hypersonic speed, produces reactions that alter the chemical structure of the air. The following list shows the major chemical reactions for air as a function of the temperature (at the stagnation point) at which, roughly, these reactions commence, and speeds in fps and Mach numbers at 100,000 ft altitude:

| | Deg F | Speed Fps | Mach No. |
|---|---|---|---|
| Vibration | 1500 | 4000 | 4 |
| Dissociation | 4000 | 7000 | 7 |
| Ionization | 14,000 | 17,000 | 17 |

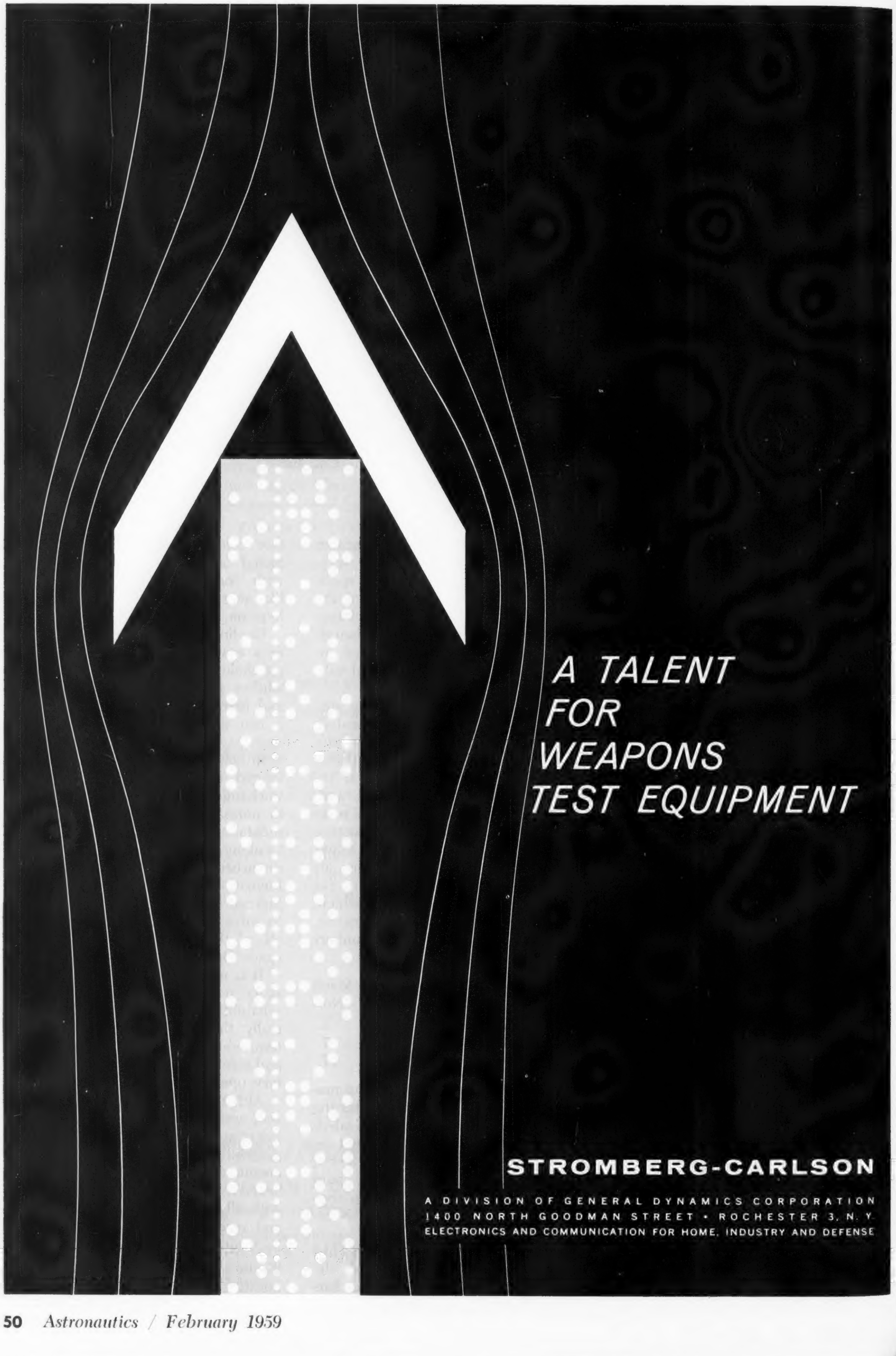
The use of nose cones, ablating materials, etc., can be used to re-enter the earth's atmosphere safely. Sealed-cabin air temperatures should not be allowed to reach 44.8 C (113 F), since this is the dermal (skin) pain threshold. If body temperature rises above 106 F, internal damage is expected at the cellular level.

Despite excellent contributions (like WADC-TR Report 53-346) in the field of thermal stress in humans, further tolerance testing of both protected and unprotected conditions, with combinations of other stresses like acceleration, noise, vibration, and hypoxia, is required.

Confinement and isolation of man in a space cabin may lead to major psychological problems. Laboratory studies cannot simulate the anxiety and fear arising from being sealed in a can and knowing that one is in space, where no man can quickly extend help in case of trouble. On prolonged flights, the monotony of an unchanging environment may produce in normal human passengers striking mental abnormalties, such as impaired thinking, childish emotional responses, disturbed visual perception, and hallucinations. Tests like the 60-day submerged trip of the Sea Wolf will help to solve many, but unfortunately not all, of the psychological problems of space flight.

It is not the hostile environment of space per se, but rather the over-all reliability of the spaceship, and especially the complex sealed-cabin system, which will determine the success and safety of orbital, lunar, and planetary operations.

Although missile system reliability is of great importance to the astronaut, the consequences of a component failure will depend on the type of failure encountered. Failures can be minimized by an adequately designed cabin with all the necessary escape survival and recovery devices and techniques built into the system. As an example, if, in a biosatellite operation, the booster vehicle failed, the whole


A TALENT FOR WEAPONS TEST EQUIPMENT
STROMBERG-CARLSON
A DIVISION OF GENERAL DYNAMICS CORPORATION
1400 NORTH GOODMAN STREET • ROCHESTER 3, N. Y.
ELECTRONICS AND COMMUNICATION FOR HOME, INDUSTRY AND DEFENSE

manned sealed cabin could become an escape capsule by means of rocket separation and use of appropriate recovery system, depending on the velocity and altitude at time of failure. Thus, the safety of the human does not need to be totally dependent on the reliability of the missile system, but rather on the reliability of the complex sealed-cabin system.

**Time-Span**

The first exploratory manned space flights will probably be confined to a time-span of several hours to perhaps a couple of days and utilize a cabin system which will in all probability be made up of existing components with a known reliability for functioning times up to 100 hr. However, if much longer flights are contemplated—a lunar trip, or a Mars expedition which might last as long as 1000 days—the design of a reliable sealed-cabin system becomes increasingly complex. In all probability, the system will follow the exponential law of reliability: $R = e^{-rt}$, where $r$ is the constant hazard and $t$ the operating time. This law describes random failure of elements in the system, in contrast to the gaussian law for failure through wear.

Obviously, absolute reliability is impossible, either in degree or in time. But the proper design, selection, and use of components and subsystems in making up the sealed cabin can produce almost any degree of reliability short of 100 per cent.

It would appear unrealistic to expect the utmost in reliability and performance from a small, lightweight, and extremely complex sealed-cabin system when we are not as yet even sure of all the environmental factors we will find in space. With the exception of the Strato-Lab and Manhigh cabins, our knowledge of the over-all reliability of a sealed cabin is somewhat vague, because cabin systems for use in space flight missions have not as yet been completely designed, let alone fabricated in numbers and tested to failure under all types of environmental conditions.

Present avionic equipment, with a mean time-to-failure of 100 hr, can give us an acceptable 78.7 per cent reliability for one-day orbital flight. However, extending flight time to 10 days and using the same mean time-to-failure of equipment gives a reliability of only 9 per cent. It would certainly appear possible to raise the present 100-hr mean time-to-failure by a factor of 10 to 1000 hr. If this could be accomplished, we could achieve 97.6 per cent reliability for a one-day flight and 78.7 per cent reliability for a 10-day flight.

However, time-to-failure even of 1000 hr would provide only 9 per cent reliability for 100-day flights. To achieve an acceptable 78.7 per cent reliability for a 100-day flight would require use of equipment with a mean time-to-failure of 10,000 hr, and this would jump to 100,000 hr for a 1000-day trip.

With our present technology, these last times-of-failure are unrealistic. Paralleling of systems will help somewhat from the standpoint of reliability but adds to over-all system weight. In addition, it does not seem to offer the advantages of in-flight maintenance.

Discussions with others who have studied this problem indicate that the human occupants of the cabin are the key to system reliability. A crew which included some highly trained system specialists would be able to maintain automatic equipment and insure a high degree of reliability.

Predicting and allocating functions for man and machine in space vehicle operation, guidance, etc., may not be easy, but, from the standpoint of equipment reliability at least, the human being as troubleshooter, maintenance man, and repair man has a definite function and reason for being in space.

## Thermal Properties Symposium To Be Held Feb. 23–26

A Symposium on Thermal Properties, sponsored by the ASME Heat Transfer Div. in cooperation with the the Purdue Univ. Thermophysical Properties Research Center, will be held at Purdue Feb. 23–26. Subjects to be treated include theoretical estimation of transport properties, reviews of recent work in transport properties, thermodynamic properties of gases and liquids, PVT data and equation of state, thermodynamic properties of boron compounds, experimental transport properties, high-temperature transport properties of metals and ceramics, and high-temperature thermodynamic properties of gases. Y. S. Touloukian of the Purdue School of Mechanical Engineering is general chairman of the symposium.

## Red Faces Dept.

The beautiful cover photograph on the January 1959 issue, showing three new infrared optical devices, was inadvertently run without a credit line. The photo was specially taken for ASTRONAUTICS by Texas Instruments, Inc., which developed the three devices pictured in the photo.

# ARS news

## Flight Testing Conference Program To Be Held in Daytona Beach, March 23–25

The first national conference ever held on one of the nation's newest "arts" will take place under ARS auspices in Daytona Beach, March 23–25. Some 500 engineers and scientists occupied with flight testing missiles, satellites, and space probes are expected to convene at the Daytona Beach and Princess Issena Hotels for a three-day meeting which will feature nine technical sessions, including some 42 papers.

Classified sessions on Missile Performance, Flight Experience, Instrumentation, and Range Support, sponsored by the Air Force, will parallel unclassified sessions on Ground Support, Data Systems, Countdowns, and Pre-Launch Problems.

Addressing luncheons at the two-day meeting will be David A. Young of the Advanced Research Projects Agency and Rear Adm. John T. Hayward, Assistant Chief of Naval Operations. The banquet on Tuesday, March 24, will be opened by Maj. Gen. D. N. Yates, Commander of the Air Force Missile Test Center, and the featured speaker will be Homer J. Stewart of NASA.

The third day of the meeting will be highlighted by a classified tour of Cape Canaveral. Gen. Yates will preside over a secret briefing at the Princess Issena Hotel, and then buses will take registrants (limited to 250) down the Florida Coast to the Cape for 15-minute stops at the Atlas, Polaris, Thor, Jupiter, Snark, and Central Control areas.

Responsible for organizing the program for the meeting is Dr. John Sterner, Director of Flight Test Operations at Space Technology Laboratories, Patrick Air Force Base. General Chairman is James F. Thompson Contract Manager of RCA Service Company. Also very active in the arrangements for the meeting, which is being held in cooperation with the Florida Section of ARS, are the 1958 and 1959 Section Presidents, Capt. R. F. Sellars and B. G. MacNabb.

The complete program follows:

**Monday, March 23**

**GROUND SUPPORT**

**10:00 a.m.** **Palm Room, Princess Issena**

Chairman: N. B. Chase, Lockheed Missile Systems Div., Patrick AFB, Fla.

✦Modern Launch Facility, Warren F. Opitz, The Martin Co., Patrick AFB, Fla. (745-59)

✦Propulsion Ground Support, A. J. Pickett, Army Ballistic Missile Agency, Patrick AFB, Fla. (746-59)

✦Operational Problems with High Pressure Helium, William H. Lawrence, Edwards AFB, Calif. (747-59)

✦Liquid Propellant Handling, John W. Schultz, Pan American World Airways, Patrick AFB, Fla. (748-59)

**DATA SYSTEMS**

**10:00 a.m.** **Main Dining Room, Princess Issena**

Chairman: Maj. R. C. Sellers, Jr., Air Force Missile Test Center, Patrick AFB, Fla.

✦Electronic Processing and Analysis of High Frequency Data, William C. Adams, Edwards AFB, Calif. (749-59)

✦Real Time Data Processing for Impact Prediction, Ralph P. Graeber, RCA Service Co., Patrick AFB, Fla. (750-59)

✦Target Acquisition Data Handling System for Space Tracking, E. T. Hatcher, RCA Service Co., Patrick AFB, Fla. (751-59)

✦Command Telemetry, Leonard S. Taylor, White Sands Missile Range, N.M. (752-59)

**LUNCHEON**

**12:00 Noon** **Marine Room, Daytona Plaza**

Toastmaster: B. G. MacNabb, 1959 President, ARS Florida Section.

Speaker: David A. Young, Advanced Research Projects Agency.

**COUNTDOWNS**

**2:00 p.m.** **Palm Room, Princess Issena**

Chairman: G. T. Willey, The Martin Company, Cocoa Div., Patrick AFB, Fla.

✦Missile Countdowns, John S. Harrison, Convair-Astronautics, San Diego, Calif. (753-59)

✦Thor Countdown Concepts, T. J. Gordon, Douglas Aircraft Co., Inc., Patrick AFB, Fla. (754-59)

✦Automatic Countdown Checkout for Defensive Missile Systems, Herbert W. Bethel, Boeing Airplane Co., Seattle, Wash. (755-59)

✦Integrated Automatic Missile Checkout and Testing Program, N. A. Marshall, Lockheed Missile Systems Div., Sunnyvale, Calif. (756-59)

✦Missile Range Meteorology, Maj. R. F. Durbin, Air Force Missile Test Center, Patrick AFB, Fla. (757-59)

**MISSILE PERFORMANCE AND INSTRUMENTATION**
(Secret)

**2:00 p.m.** **Main Dining Room, Princess Issena**

Chairman: George Shaw, Radiation, Inc., Melbourne, Fla.

✦Evaluation of Bomarc Guidance Philosophy in Relation to Flight Test Performance, H. B. Waterman and S. I. Dees, Boeing Airplane Co., Seattle, Wash.

✦Problems in Determining Rotational Stability of Optical Alignment Reference Stations, Paul E. Fisher, Arma Div., American Bosch Arma Corp., Patrick AFB, Fla.

✦Flight Test Evaluation of Missile Control Systems, Alfred P. Fay, Douglas Aircraft Co., Inc., Santa Monica, Calif.

✦Some Aspects of Flight Test Problem Solving for Rocket Propulsion Systems, Dieter K. Huzel, Rocketdyne, A Division of North American Aviation, Inc., Canoga Park, Calif.

✦CW Trajectory Measurements for Ballistic Missiles & Space Vehicles, Frank P. Stoklas, RCA Service Co., Patrick AFB, Fla.

✦Results of Trans-Horizon Tracking Tests at Point Mugu, Robert H. Paul, White Sands Missile Range, N.M.

**FLIGHT EXPERIENCE**
(Secret)

**8:00 p.m.** **Main Dining Room, Princess Issena**

Chairman: B. G. MacNabb, Convair-Astronautics, Patrick AFB, Fla.

✦Nike Development Testing at White Sands Missile Range, Richard W. Benfer, Bell Telephone Laboratories, Inc., White Sands Missile Range, N.M.

✦Development & Operations at the Pacific Missile Range, Comdr. Robert F. Freitag, Pacific Missile Range, Point Mugu, Calif.

✦Flight Testing of Atlas Missiles at the Atlantic Missile Range, George S. Cherniak and John T. Blake, Space Technology Laboratories, Inc., Patrick AFB, Fla.

**Tuesday, March 24**

**PRE-LAUNCH PROBLEMS**

**9:30 a.m.** **Palm Room, Princess Issena**

Chairman: T. J. Gordon, Douglas Aircraft Inc., Patrick AFB, Fla.

✦Problems in Servicing Nuclear Rockets, Sidney G. Rumbel, Aerojet-General Corp., Azusa, Calif. (758-59)

✦Missile Handling Problems of Flight Test Programs, Clarence M. Wedertz, Douglas Aircraft Co., Inc., Santa Monica, Calif. (759-59)

✦Philosophy of Pre-Launch Preparations for R&D Missiles, Robert E. Moser, Army Ballistic Missile Agency, Patrick AFB, Fla. (760-59)

✦Atlas Missile Instrumentation Checkout, Walter S. Hicks, Convair-Astronautics, Patrick AFB, Fla. (761-59)

✦Evaluation of Preflight Risks by Means of High Speed Digital Simulation, J. D. Brinkerhoff, Boeing Airplane Co., Seattle, Wash. (762-59)

**INSTRUMENTATION**
(Secret)

**9:30 a.m.** **Main Dining Room, Princess Issena**

Chairman: K. M. McLaren, RCA Service Co., Patrick AFB, Fla.

✦Use of Infra-red in Flight Testing, Louis F. Drummeter, Jr., Naval Research Laboratory, Washington, D.C.

✦Problems Associated with Making Missile Re-Entry Radiation Measurements, David D. Woodbridge and Ray V. Hembree, Army

Ballistic Missile Agency, Huntsville, Ala.
✦Shipborne Instrumentation for Terminal Ballistic Measurements, Re-Entry Research and Manned Capsule Recovery, Raymond V. Godfrey, RCA Service Co., Patrick AFB, Fla.
✦Factors Affecting Telemetry Signals during Ballistic Missile Powered Flight, Horst A. Poehler, Space Technology Laboratories, Inc., Patrick AFB, Fla.
✦Operational Characteristics of the TLM-18 Sixty-Foot Automatic Tracking Telemetry Antenna, Frank Coxe, Radiation, Inc., Melbourne, Fla.

**LUNCHEON**

**12:00 Noon — Marine Room, Daytona Plaza**

Toastmaster: Capt. R. F. Sellars, 1958 President, ARS Florida Section
Speaker: Rear Admiral John T. Hayward, Asst. Chief of Naval Operations.

**DATA SYSTEMS**

**2:00 p.m. — Palm Room, Princess Issena**

Chairman: C. L. Carroll, Jr., RCA Service Co., Patrick AFB, Fla.
✦A Simple Formula for Prediction and Automatic Scrutation, Richard J. Duffin and Thomas W. Schmidt, Office of Ordnance Research, Durham, N.C. (763-59)
✦Real Time Analysis—New Approach in Flight Testing, Guenther Hintze, White Sands Missile Range, N.M. (764-59)
✦A Solution to a Broad Class of Estimation Problems Arising in Missile Testing, Duane Brown, RCA Service Co., Patrick AFB, Fla. (765-59)
✦Project Space Track at AFMTC, Walter H. Manning, Air Force Missile Test Center, Patrick AFB, Fla. (766-59)
✦Results and Experiences from Satellite Track with AN/FPS-16 Instrumentation Radars, A. E. Hoffman-Heyden, RCA Service Co., Patrick AFB, Fla. (767-59)

**RANGE SUPPORT**
**(Secret)**

**2:00 p.m. — Main Dining Room, Princess Issena**

Chairman: R. S. Mitchell, Vice-President, Guided Missiles Range Division, Pan American World Airways, Patrick AFB, Fla.
✦An Automated Real Time Range Complex (ARTRAC) for WSMR, W. E. Miller, Jr., White Sands Missile Range, N.M.
✦Trends in Range Instrumentation Requirements, V. R. Widerquist, Space Technology Laboratories, Inc., Patrick AFB, Fla.
✦Capacity of the Atlantic Missile Range, Col. Paul T. Cooper, Air Force Missile Test Center, Patrick AFB, Fla.
✦Range Safety at Atlantic Missile Range, Norman D. Mallory, RCA Service Co., Patrick AFB, Fla.
✦Atlantic Missile Range Recovery Operations, W. G. Gaskill, Pan American World Airways, Patrick AFB, Fla.

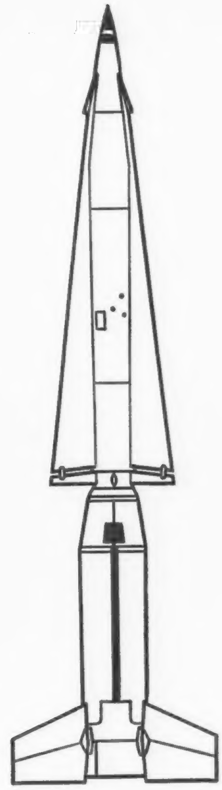
**RECEPTION**

**6:00 p.m. — Palm Room, Princess Issena**

**BANQUET**

**7:00 p.m. — Main Dining Room, Princess Issena**

Toastmaster: Anthony Conrad, Vice-President, RCA Service Co.
Introduction: Maj. Gen. Donald N. Yates, Commander, AFMTC.
Speaker: Homer J. Stewart, National Aeronautics and Space Administration, Washington, D.C.



## The man:

A U. S. Army missileman working with Nike Hercules missile equipment. The modern Army relies heavily on the special skills and knowledge of men like this who are trained extensively in military schools, and supported technically in the field by Army Ordnance Corps, Western Electric and Douglas field service men.

## The mission:

Defense of U. S. cities. Army Nike Hercules units are already on duty at many key points...have the important assignment of guarding against enemy aircraft.

## The missile:

Douglas-built Nike Hercules, product of a Douglas-Western Electric-Army Ordnance team, has successfully engaged supersonic drone targets at altitudes well over 60,000 feet. Other drone targets have been destroyed up to 100,000 feet, and at ranges beyond 75 miles.

| | |
|---|---|
| **Status** | **Combat ready** |
| **Range** | **75 miles plus** |
| **Speed** | **Supersonic** |
| **Warhead** | **Nuclear or conventional** |
| **Service** | **U. S. Army** |

*Depend on* **DOUGLAS**

*The Nation's Partner in Defense*

Wednesday, March 25
AFMTC TOUR
(Secret)

Limited to first 250 whose clearance forms are approved and acknowledged in writing.

8:00 a.m. —Briefing—Main Dining Room, Princess Issena
9:30 a.m. —Depart Princess Issena Hotel via Greyhound buses
11:00 a.m. —Arrive Cape Canaveral
11:15 a.m. —Lunch—Pan American Cafeteria
12:00 Noon—Tour
2:00 p.m. —Depart Cape Canaveral
3:30 p.m. —Arrive Princess Issena Hotel

Tour will include stops at ATLAS, THOR, JUPITER, POLARIS, SHIP MOTION SIMULATOR, SNARK, and CENTRAL CONTROL for CONFIDENTIAL briefings of about 15 minutes each.

## New Sections, Student Chapters Approved

The Board of Directors of the American Rocket Society approved the following new sections and chapters at their meeting last November 20, during the 13th Annual Meeting held in New York City.

### Sections

Central Indiana—Indianapolis, Ind.
Central New York—Liverpool, N.Y.
Pittsburgh—Pittsburgh, Pa.
Palm Beach—Palm Beach, Fla.

### Chapters

City College of New York—N.Y., N.Y.
Univ. of Connecticut—Storrs, Conn.
Drexel Institute of Technology—Philadelphia, Pa.
Fenn College—Cleveland, Ohio
Marquette Univ.—Milwaukee, Wis.
Univ. of Missouri—Columbia, Mo.
Newark College of Engineering—Newark, N.J.
Univ. of Oklahoma—Norman, Okla.
Univ. of Texas—Austin, Tex.
Tri-State College—Angola, Ind.
Vanderbilt Univ.—Nashville, Tenn.
Univ. of Hartford—Hartford, Conn.

## 10th IAF Congress Set for Aug. 31–Sept. 5; Abstracts Due April 15, Manuscripts May 15

The 10th International Astronautical Congress will he held at Church House, Westminster, London, during the week of Aug. 31 to Sept. 5, the British Interplanetary Society, host society for the meeting, announced last month.

Situated in the neighborhood of the Houses of Parliament, Church House possesses a number of spacious meeting halls, the largest holding 800 people, several committee rooms and a restaurant.

Also planned for the Congress is a second Space Law Symposium, similar to the one held last year in Amsterdam. Site of this meeting will be announced in the near future.

BIS is also planning to precede the IAF Congress with a two-day British Commonwealth Space Flight Symposium. This will be held Aug. 28–29, also at Church House.

Prospective authors are invited to submit papers for this year's IAF Congress through the ARS Screening Committee, now being organized. Papers are being sought in the following range of astronautical topics:

1. Research applications of satellites and space probes
2. Existing and proposed projects for manned and unmanned space vehicles
3. Conventional and unconventional space propulsion systems
4. Problems in dynamics, control, and navigation
5. Re-entry problems
6. Biological and medical aspects of manned space flight
7. Legal problems

ARS members who desire to submit papers for presentation at the meeting are requested to notify ARS headquarters by April 15. This notification should be accompanied by a brief (50–200 word abstract) in triplicate. Final manuscripts must be submitted no later than May 15. Three copies of the paper will be required, and this deadline must be adhered to in order to allow adequate time for preprinting.

Proceedings of the Congress will be published by Springer-Verlag of Vienna.

## Northwestern Symposium to Feature Dynamics of Conducting Fluids

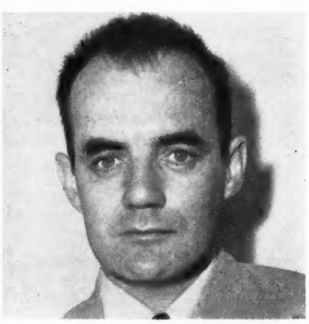
The 1959 ARS-Northwestern Univ. Gas Dynamics Symposium, to be held Aug. 24–26 at Evanston, Ill., will cover the subject of "Dynamics of Conducting Fluids," it has been announced by the co-chairmen of the Symposium, Ali Bulent Cambel of Northwestern and Dr. John B. Fenn of Project Squid, ONR, Princeton Univ.

This year's Symposium will be held under the cognizance of the ARS Hydromagnetics Committee. Chairman of the Committee is Milton U. Clauser of Space Technology Laboratories.

Abstracts of papers for the Symposium should be sent to Prof. Cambel or Dr. Fenn for consideration. Final deadline date for manuscripts is May 22.

SYMPOSIUM CO-CHAIRMEN

Ali B. Cambel



John B. Fenn

**SECTIONS**

**Alabama:** Twenty-six members attended the Oct. 10 tour of the Oak Ridge National Laboratories. Guests of Union Carbide, which operates these laboratories for the AEC, they heard a talk on the dual plasmatron and its applications to ion propulsion. The members saw the natural uranium-graphite reactor, which has been in operation since 1942, making it the oldest operating reactor in the world; two enriched-uranium research reactors of the swimming pool type; and a 330-ft suspension system for testing airborne reactors.

—**David R. Mills**

**Detroit:** At the Dec. meeting, **Leslie M. Jones,** supervisor of the Univ. of Michigan High Altitude Engineering Laboratory, reviewed the results of U.S.–U.S.S.R. cooperation in IGY high-altitude research. With the aid of color slides, Dr. Jones described Russia's meteorological rocket, which in dimensions is quite similar to the Aerobee, and its geophysical rocket, which looks somewhat like the Redstone missile. He reported that Russian findings in upper-air research, particularly in the areas of pressure, temperature, density, and diffusion separation of light and heavy gases, completely confirmed U.S. test findings.

Dr. Jones also showed excellent photos and instrumentation diagrams of the three Sputniks. In view of official Soviet announcements, he thinks that the instrumentation for Sputniks II and III were identical to that used in the Russian geophysical rocket, specific details of which have never been officially announced. He also guesses that the geophysical rocket itself may well have been the last stage of their satellite vehicle.

Summing up the results of the IGY high-altitude rocket research program, Dr. Jones indicated that relationships between Russian and American scientists were surprisingly "friendly and fruitful."

—**Dan P. Lutzeier**

**Holloman:** The section has enjoyed very fine dinner meetings the past two months. Some 125 members and guests attended the dinner meeting in November. President Knox Millsaps, opening the after-dinner portion of the meeting, introduced special guests—Maj. Gen. Laidlaw, commander of the Army White Sands Missile Range, Brig. Gen. Hooks, commander of the AF Missile Development Center, the mayors of Alamogordo and Las Cruces, and the evening's speaker, **Col. Benjamin P. Blasingame,** head of the Astronautics Dept. of the USAF Academy and former project officer for the Titan ICBM.

Col. Blasingame talked on the approach taken in teaching astronautics at the Academy. Students at the Academy, he explained, approach the study of astronautics by retracing the

## Old Reactor, New Audience

**Members of the Alabama section, touring Oak Ridge National Laboratories as guests of Union Carbide, stopped here before the oldest operating reactor in the world.**

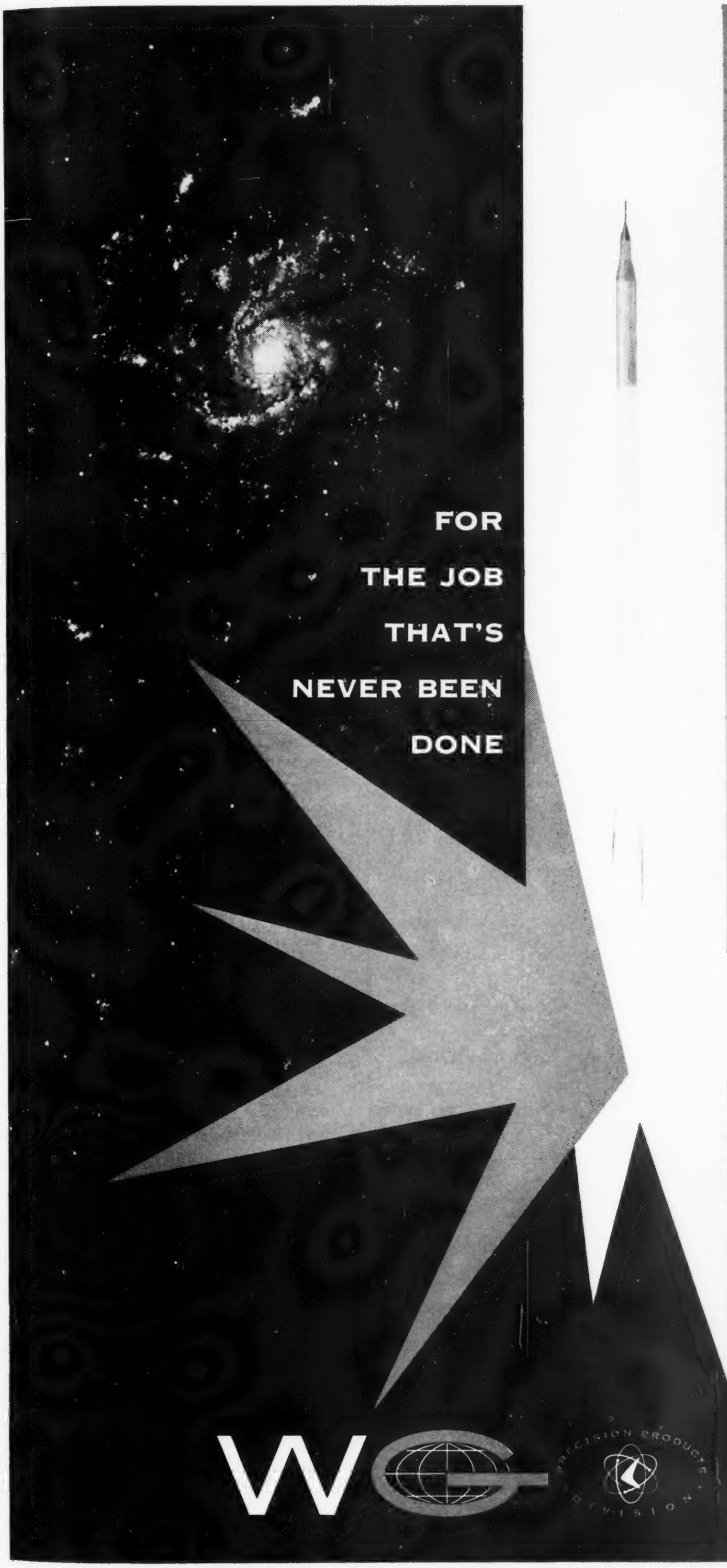
## What Was in the Sputniks?

**Reviewing U.S.–U.S.S.R. cooperation on IGY high-altitude research for the Detroit section, Leslie M. Jones, supervisor of the Univ. of Michigan High Altitude Engineering Laboratory, reported that the instrumentation for Sputniks was probably identical to that used in the Russian geophysical rocket.**

**ARS 1959 Paper Deadlines**

| Date | Meeting | Location | Deadline |
|---|---|---|---|
| March 23–25 | Flight Testing Conference | Daytona Beach, Fla. | Past |
| April 30–May 1 | Controllable Satellites Conference | MIT | Feb. 20 |
| May 25–27 | National Telemetering Conference | Denver, Colo. | March 19 |
| June 8–11 | Semi-Annual Meeting | San Diego, Calif. | March 9 |
| Aug. 24–26 | Gas Dynamics Symposium, Dynamics of Conducting Fluids | Northwestern Univ. | May 22 |
| Aug. 31–Sept. 5 | 10th IAF Congress | Westminster, London | May 15 |
| Sept. 24–25 | Solid Propellants Conference | Princeton Univ. | June 22 |
| Nov. 16–20 | 14th Annual Meeting | Washington, D.C. | Aug. 17 |

Send all papers to Program Chairman, ARS, 500 Fifth Ave., New York, 36, N.Y., or to appropriate committees


FOR
THE JOB
THAT'S
NEVER BEEN
DONE
WG
PRECISION PRODUCTS DIVISION

history of science, and especially astronomy. He went on to say that, after an intensive treatment of free-flight trajectories, an Academy class would turn to the problems of powered trajectories, rocket performance equations, rocket engine design, and elementary guidance and control, concluding the course with case studies of actual missile and rocket designs, such as Titan, Atlas, or Thor.

Members met for the Dec. dinner meeting in the banquet room of the Desert Aire Motor Hotel in Alamogordo. President Millsaps opened the after-dinner portion of the program with introductory remarks on the career of the guest of honor and principal speaker of the evening, **William Randolph Lovelace II,** one of the real pioneers in aero and space medicine, a director of the Lovelace Foundation, and recently appointed chairman of NASA's advisory committee on human factors.

Dr. Lovelace spoke on the growth of aeromedical and aerospace medicine. He began by referring graciously to AFMDC's work in areas which have contributed to the solution of problems in aeromedicine and in the coming age of space flight. He observed that there has been a rapproachment between the life and physical scientists in the past quarter century. This cooperation, he believes, has been of great value to the advancement of aviation, and bids well to be a fundamental part of space science.

He then went into some detail on modern methods of crew selection, pointing out that the NASA can use the roster of active and experienced airplane test pilots as a source for recruiting satellite or space vehicle pilots. Starting with young, healthy, and motivated men of this type, he sees no reason why the flight surgeon and psychiatrist can not find the men who will be needed.

Dr. Lovelace mentioned the benefits to regular diagnosis which have resulted from extensive aeromedical research. For example, the use of high-speed X-ray equipment in evaluating spinal configurations of test pilots who will endure high acceleration forces taught the medical profession improved diagnostic techniques for spinal pathology. Dr. Lovelace illustrated this portion of his lecture with a group of slides which pictured a variety of methods and apparatus for selecting crew men. The audience was quick to catch his point that research may prove to have application to many related activities.

He was concerned—as are all of us interested in the future of manned space flight—in the present inability to simulate weightlessness for more than brief periods. He sees no immediate remedy to this in sight, but stated that the use of a large ballistic missile, shot over water and carrying a recoverable manned capsule, appears to be a quick way of sending a volunteer on a "weightless" flight to find out "how he liked it." He mentioned that another problem which has not been completely solved is that of the influence of vibration and noise. The medical men want to know if these stresses are additive, and hope to know some day to what degree they are cumulative.

Dr. Lovelace closed his talk with a discussion of the types of orbital vehicles which will probably appear, and with a description of the first manned satellite capsule as envisioned by the NASA.

—**A. Lee Zuker,** Lt. USAF, and **Harry L. Gephart,** Lt. Col., USAF

## On the calendar

**1959**

| | |
|---|---|
| Feb. 3–5 | 14th Annual Technical and Management Conference of the Reinforced Plastics Div. of The Society of the Plastics Industry, Edgewater Beach Hotel, Chicago. |
| Feb. 5–6 | Industrial Management Engineering Conference at Illinois Inst. of Technology, Metallurgical and Chemical Engineering Bldg., Chicago. |
| Feb. 23–26 | Symposium on Thermal Properties, sponsored by ASME and Purdue Univ., at Purdue Univ., Lafayette, Ind. |
| March 3–5 | 1959 Western Joint Computer Conference, sponsored by IRE, AIEE, and Assn. for Computing Machinery, Fairmont Hotel, San Francisco. |
| March 8–11 | Turbine in Action Symposium, sponsored by ASME Gas Turbine Div., Cincinnati, Ohio. |
| March 11–12 | 9th Annual Iron and Steel Conference, sponsored by ISA Pittsburgh Section, Pittsburgh. |
| March 19–20 | Flight Propulsion Meeting, sponsored by IAS, Hotel Carter, Cleveland, Ohio. |
| **March 23–25** | **ARS Flight Testing Conference, Daytona Beach, Fla.** |
| March 31–April 2 | Millimeter Waves will be the theme of 9th International Symposium of Polytechnic Institute of Brooklyn (N.Y.) Microwave Research Inst., co-sponsored by AFOSR, Army Signal R&D Lab, ONR, and IRE. |
| April 5–10 | 5th Nuclear Congress of Engineers Joint Council, Cleveland Auditorium, Ohio. |
| April 6–10 | 40th Annual Convention of the American Welding Society, Chicago. |
| April 12–19 | World Congress of Flight, sponsored by Air Force Assn., Las Vegas, Nev. |
| April 22–24 | 3rd Annual Technical Meeting of the Institute of Environmental Engineers, LaSalle Hotel, Chicago. |
| **April 30–May 1** | **ARS Controllable Satellites Conference, MIT, Cambridge, Mass.** |
| May 4–7 | 5th ISA National Instrumentation Flight Test Symposium, Seattle, Wash. |
| **May 25–27** | **National Telemetering Conference, co-sponsored by ARS, AIEE, IAS, and ISA, Denver, Colo.** |
| **June 8–11** | **ARS Semi-Annual Meeting and Astronautical Exposition, San Diego, Calif.** |
| June 11–13 | 1959 Heat Transfer and Fluid Mechanics Institute, Univ. of Calif., Los Angeles. |
| **Aug. 24–26** | **ARS Gas Dynamics Symposium, Dynamics of Conducting Fluids, Northwestern Univ., Evanston, Ill.** |
| Aug. 28–29 | British Commonwealth Space Flight Symposium, Westminster, London. |
| **Aug. 31–Sept. 5** | **10th Annual International Astronautical Federation Congress, Westminster, London.** |
| **Sept. 24–25** | **ARS Solid Propellants Conference, Princeton Univ., Princeton, N.J.** |
| **Nov. 16–20** | **ARS 14th Annual Meeting and Astronautical Exposition, Washington, D.C.** |

*...speaking of*

*Missile Ground Support* ***EQUIPMENT***

# WE CONTRIBUTE COST-SAVINGS TO THE BOMARC PROGRAM

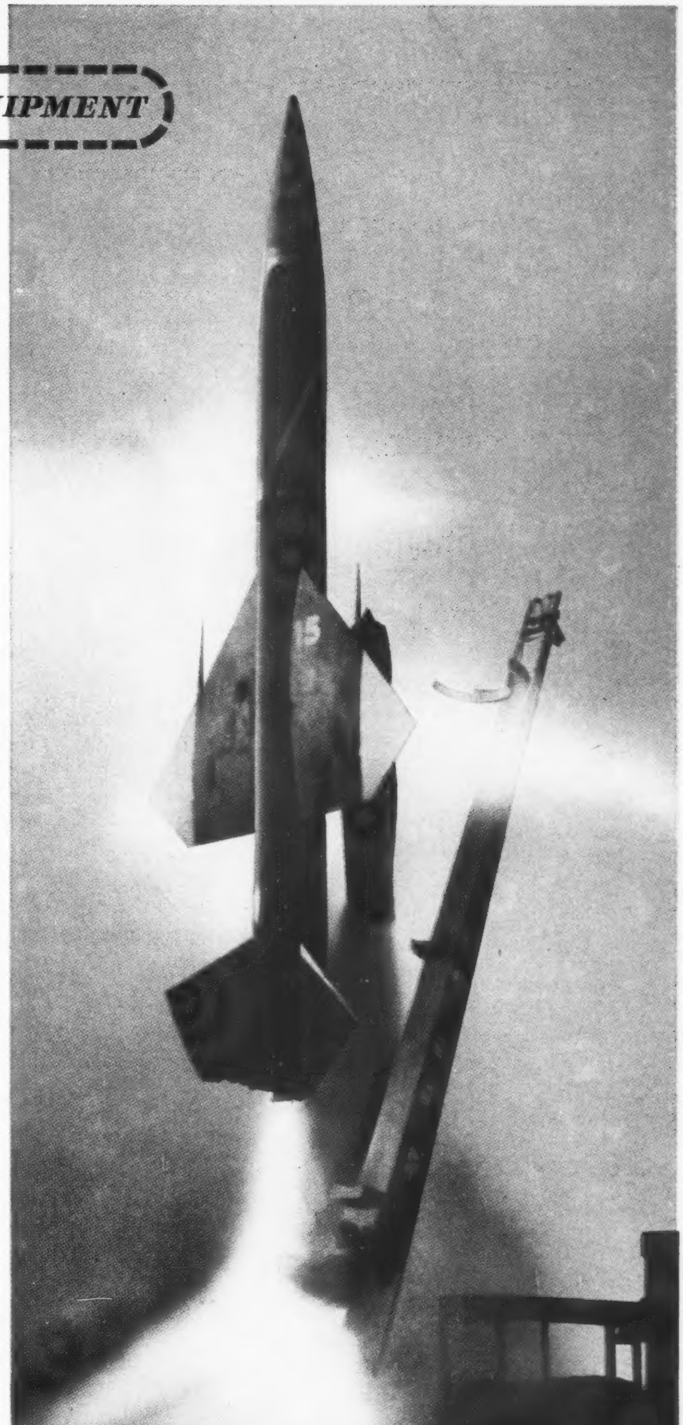
When the Boeing Bomarc IM-99 is launched, FMC-built ground support equipment will be used.

Erectors, launch bases, flame deflectors and power control units, production-engineered and manufactured by FMC under a Boeing contract, automatically position the long-range surface-to-air missiles for firing.

FMC's capability for economical production, resulting from over 17 years' experience in designing and producing defense materiel, has effected important savings in the ground support equipment phase of the Bomarc program.

FMC will assume full responsibility for any phase of your missile ground support equipment project, fixed or mobile, from design concept through development, engineering and production. Long experience with military requirements and completely integrated facilities devoted exclusively to the manufacture of defense equipment are further assurance of on-schedule delivery. *Consult with FMC at the initial stage of project planning.* Contact us today for more information.

*Creative Engineers: Find stimulating challenge at FMC's Ordnance Division.*



Operated by the Air Defense Command, a Boeing Bomarc climbs skyward from its launcher. FMC is building ground support equipment for this supersonic missile.

BOEING AIRPLANE COMPANY PHOTO

*Putting Ideas to Work*

fmc FOOD MACHINERY AND CHEMICAL CORPORATION ®

FOOD MACHINERY AND CHEMICAL CORPORATION

**Ordnance Division**

Missile Equipment Section 2-L

1105 COLEMAN AVENUE, SAN JOSE, CALIF.

## Space Talk Glossary

Republic Aviation Corp. has just issued a 20-page glossary of astronautical terms. Titled "Space Talk," the booklet lists and defines 133 common words and expressions, ranging from "abort" through "zip fuel."

## Polaris Test Ship

Commissioned recently, the USS Observation Island, a 17,600-ton vessel modified for firing Polaris test missiles at sea, will soon be operating in conjunction with the ship's motion simulator at Cape Canaveral, in an extension of the Polaris land-based flight-test program being conducted by the Navy's Special Projects Office and Lockheed Missile Div.

## NASA Giant Booster Job

Rocketdyne, Div. of North American Aviation Inc., has been selected by NASA to design and develop the 1-million-lb thrust rocket engine for space projects. The engine will be so designed that several propellant combinations can be used in it, and it will be capable of development to a thrust of 1.5 million lb. NASA expects that this program may take four to six years.

---

## Psychophysiological Aspects

(CONTINUED FROM PAGE 33)

the accumulation of carbon dioxide in the capsule; he carried prototype instrumentation for transmitting heart and respiration rate to the ground; and he made urine and blood tests in relation to stress.

In addition, three subjective psychological measurements were introduced on the Manhigh II flight. First, the pilot reported his temperature subjectively every hour on a four point scale. Second, the pilot reported his productive activity in terms of a percentage of efficiency. A normal level of activity was rated about 90 per cent. Third, he recorded all subjective comments during the flight.

In the Manhigh III flight, all these measurements were taken. Moreover, improved instruments were used to take heart and respiration rate and to measure carbon dioxide concentration. Heart rate, skin resistance, and temperature data were telemetered to the ground for the first time. Also, a camera was added which took 35-mm infrared flash photographs of the pilot approximately every 2 min throughout the flight. Urine samples were obtained as before, but not blood. Also, as before, cabin temperature, capsule pressure, balloon altitude, electrocardiogram, respiration, and skin resistance were telemetered. Thus, ground and airborne monitoring personnel had these measurements at any time without effort or attention from the pilot.

For Manhigh III, particular attention was paid to methods of monitoring psychological and psychiatric performance of the pilot. The figure on page 33 shows the kind of reporting of temperature and personal condition by the pilot. This kind of reporting was done in Manhigh I and II, but was amplified in Manhigh III by adding the factors—alertness, drive, and tension.

Simple heart-rate and respiration indicators proved extremely valuable during the Manhigh III flight, when verbal communication was temporarily lost during the period of peak stress. Both skin resistance and alertness, tension and emotional-stress measurements were highly experimental, and will require further evaluation before their significance is established. Skin- and internal-temperature information served, however, to correct values for skin resistance and thus to provide information for tabulating the heat load on the subject.

The most valuable techniques introduced in Manhigh III were a psychiatric interview conducted by Dr. Ruff and a grading of the information the pilot chose to dictate to the tape recorder.

Following the Manhigh II flight, the time spent dictating to the tape recorder was used as an index of the pilot's creativity," as indicated by the graph on page 33. This graph shows that periods of creativity correspond to periods affording new experience. The first peak, around 0930, concerned launch; the second, at 1100, concerned reaching an altitude of 100,000 ft. Throughout the afternoon, there was a gradual decline in creativity until the impetus provided by sunset at 2050. Then spontaneous activity was quickly dampened by fatigue and did not rise again until sunrise at 0600.

As an outgrowth of this analysis, and discussions with Dr. Ruff, an additional analytic technique was worked out. Tape-recorded pilot comments were classified into two groups. The first, called primary or simple observations, included statements of observed facts, such as temperature and sky color, and subjective observations of attitude, comfort, etc. The second, called secondary or derived observations, included comments showing that the pilot used inductive or deductive reasoning to reach a con-

clusion.

Secondary observations were considered a higher level of mental initiative and more indicative of creativity than primary observations. A third level of creativity was assessed for the Manhigh II flight by analyzing the errors made by the pilot in reporting mandatory factual information (pilot reports). A fourth, and the lowest level of creativity gauged, concerned "break-off" phenomenon. Unfortunately, further analysis of this type was not possible on the Manhigh II and III flights because of tape recorder malfunctions.

The concept of measuring creativity is similar to the measurements of performance described by G. T. Hauty of the USAF School of Aviation Medicine. He measured performance of neuromuscular coordination tasks requiring some decision but no imagination and no spontaneous initiative, i.e., the job was prescribed and paced by the experimenter. Creativity, being a higher mental function, should be more vulnerable to fatigue both in time and severity than the performance measured by Hauty. The technique just described for scoring mission activity in terms of creativity should thus provide valuable insight into performance decrement. Also, Dr. Hauty's observation—that prolonged concentration on a specific task with limited variations in mode and nature of sensory input leads to symptoms very similar to those described in environments of reduced sensory stimulus—warns us of a new problem area in space flight: Monotony of stimulus can be as dangerous as lack of stimulus.

Manhigh experiments have already suggested strongly that such psychophysiological research will play an important part in preparing man for space flight.

---

Based on a paper presented at the ARS 13th Annual Meeting in New York City, November 17-21, 1958.

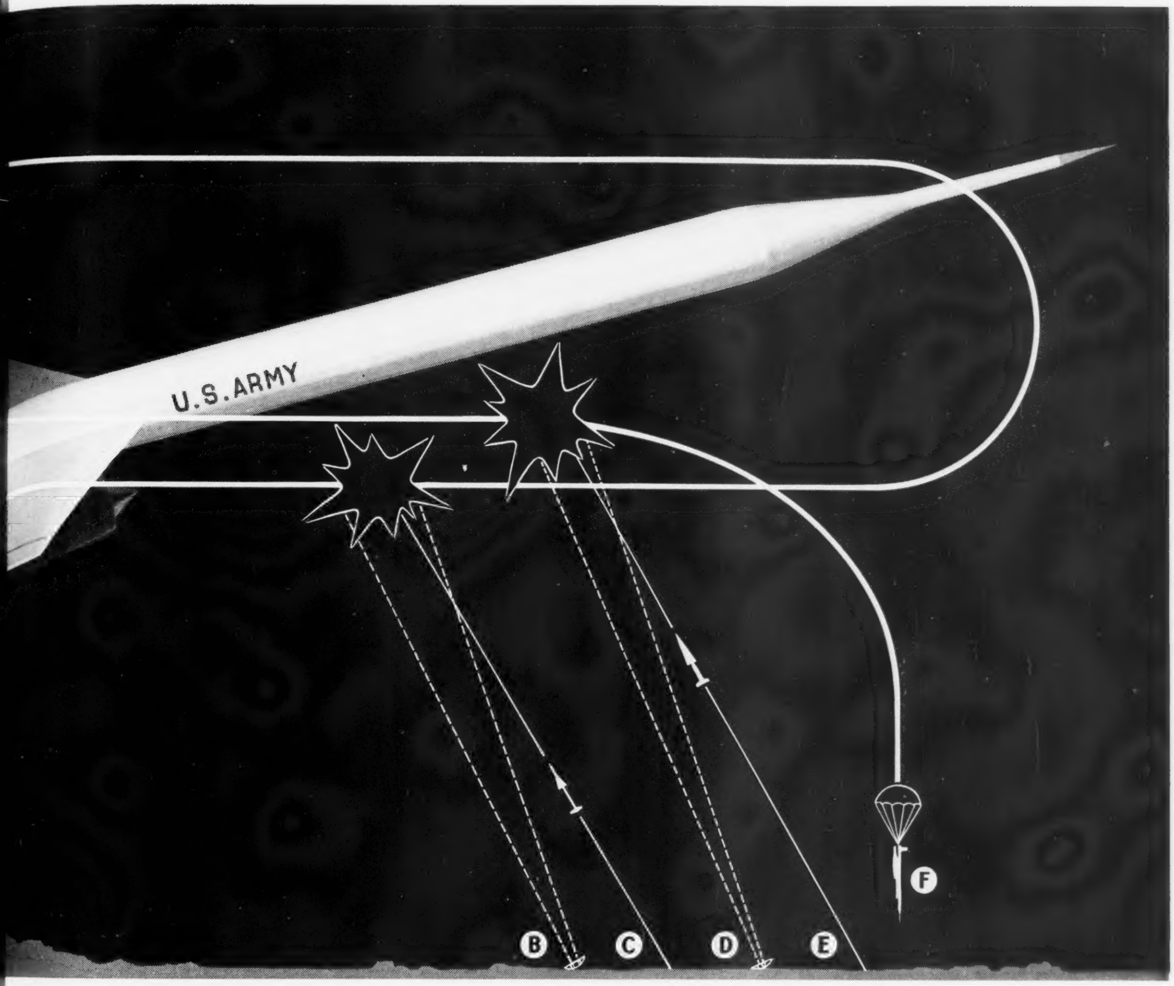
### Suggested Additional Reading

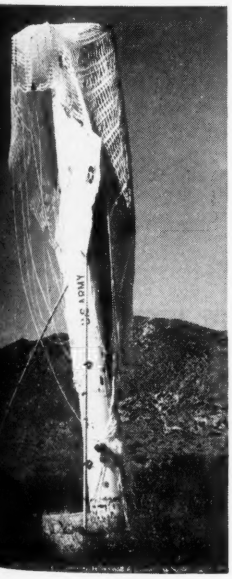
Hauty, G. T., Human Performance in the Space Travel Environment, *Air University Quarterly Review*, 10: 89–107, Summer 1958.

Henry, J. P., Some Correlations Between Psychologic and Physiologic Events in Aviation Biology, *J. Aviation Medicine*, 29: 171–179, March 1958.

Levy, E. Z., Ruff, G. E., and Thaler, V. H., Applications of a New Technique for Recording Skin Resistance Changes, ARS Preprint 679–58.

Simons, D. G., Pilot Reactions During Manhigh II Balloon Flight, *J. Aviation Medicine*, 29: 1–14, January 1958.



**Above: Entering oval flight pattern,** Q-5 attains speeds over 1500 mph. Second ground radar **(D)** and missile-launching battery **(E)** practice their marksmanship until Q-5 *Kingfisher's* fuel supply is exhausted.

**Left: Landing on its nose-spike** in a remote, uninhabited area, after floating down by parachute **(F)**, the Q-5 is recovered by U.S. Army ground crews—to be refueled and refitted for future flights.

# LOCKHEED

**LOCKHEED AIRCRAFT CORPORATION, MISSILE SYSTEMS DIVISION**

MISSILE RESEARCH & DEVELOPMENT • BALLISTIC MISSILE SYSTEMS MANAGEMENT • ROCKETRY • ULTRASONIC AERODYNAMICS • SPACE INVESTIGATIONS • NUCLEAR PHYSICS • ADVANCED ELECTRONICS • HIGH-SPEED AUTOMATIC DATA REDUCTION • RAMJET PROPULSION TESTING

# People in the news

## APPOINTMENTS

President Eisenhower has appointed ARPA chief scientist **Herbert F. York** to the new post of director of defense research and engineering in the Defense Dept. Dr. York will be outranked only by the Secretary of Defense, Deputy Secretary, and 3 service secretaries.

**Eugene B. Konecci,** formerly head of the human factors group, Douglas-Tulsa, has been appointed head of human factors and bio-astronautics at the company's Missiles and Space Engineering Div. in Santa Monica. Dr. Konecci is vice-chairman of the ARS Human Factors Committee.

**A. L. Antonio,** who directed Aerojet-General's solid propellant research and development between 1944–54, has rejoined the company as vice-president of the Chemical Div., having been general manager of General Tire and Rubber Chemical Div. for the past four years. **Dan M. Tenenbaum,** head of Aerojet's Liquid Rocket Plant Test Div., has been appointed to head all rocket testing at the company's Sacramento facilities, and **Fred Hall,** former Governor of Kansas and State Supreme Court Justice, has been appointed director of management control, Solid Rocket Plant. Other Aerojet appointments are: **George Moe,** to head of the Astronautics Lab.; **Wilbur G. Clayton,** to logistics coordinator for the Titan weapon systems program, Turbo-Machinery Div.; and **Raymond J. Melchione,** as Flight Test Center resident representative at Edwards AFB. **Gordon Banerian,** manager of the Turbo-Machinery Div., has been appointed chairman of NASA's Research Advisory Committee on Mechanical Power Plant Systems.

General Electric's Missile and Space Vehicle Dept. has appointed the following group managers: **J. Katzen,** systems design and integration; **L. L. Farnham,** vehicle engineering; **E. Fthenakis,** navigation and control; **J. Hungerford,** ground support; and **C. Botkin,** nuclear ordnance projects.

**Peter G. Kappus** has been appointed manager of the newly organized Aircraft Gas Turbine Div. Product Analysis Operation in the Flight Propulsion Lab. Dept.

**Melvin N. Gough,** NASA head of flight research at Langley Research Center, has been named director of activities at the space agency's Atlantic Missile Range, Cape Canaveral.

**George K. Johnson** has been appointed assistant manager of Lockheed's Missile Systems Div. plant in Van Nuys, in addition to Van Nuys plant production manager.

**Wayne Johnson** has joined Chicago Aerial Industries as director of engineering.

Hercules Powder Co. has staffed its new solid propellant plant at Bacchus, Utah, with **John H. Main,** as design superintendent; **William J. Rue,** as production superintendent; and the following as chemical propellant supervisors: **James O. Spitznogle,** ballistic development; **William M. Bogart,** inert components; **Edward P. Whaley,** evaluation; and **A. Richard Shoff,** instrumentation. **Loren E. Morey** and **Gordon W. McCurdy** will serve as technical specialist and technical assistant, respectively, while **John E. Greer** will be responsible for over-all management of the facility.

**John F. Cain** has been made a director and general manager of Greer Hydraulics, Inc.

**Samuel J. Davy** has been named manager of field operations, Arma Div., American Bosch Arma Corp. **Karl H. Keller,** former special projects administrator, becomes site manager of the company's Cape Canaveral Operation.

**Richard C. Mulready** becomes project engineer in charge of rocket engine development at Pratt & Whitney Aircraft's Florida R&D Center, while **Charles H. King Jr.** becomes project engineer in the program.

**R. E. Honer** has been made assistant chief engineer-electronics for Convair's San Diego Div.

**Steven Yurenka** and **Harold H. Levine** have been appointed manager and research chemist, respectively, of the Advanced Structures Research Lab of the R&D Div. of Narmco Industries, Inc.

**A. P. Albrecht** has been appointed general manager of Space Electronics Corp. Additional managerial appointments include: **R. W. Williams,** Launch Control Dept.; **A. W. Newberry,** Instrumentation Dept.; and **R. W. Sanders,** Analysis Dept. **W. A. Makofske** and **R. M. Stewart** have been named senior members of the technical staff.

**R. A. Brown,** former supervisor of design engineering, U.S. Steel Corp., has been named director of the newly established R&D Section at the company's Consolidated Western Steel Div., doing work in the atomic power, missile, avionic, and space fields. His staff will consist of **W. I. Ballentine Jr.,** as general supervisor, research and development services; **W. A. Box,** as general supervisor, design engineering; and **W. A. Saylor,** as chief metallurgist.

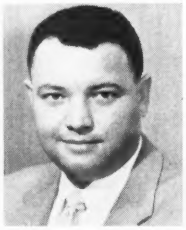
**Don R. Proctor** has been promoted from assistant chief engineer to chief engineer of Electronic Engineering Co.

**Eugene Le Baron** a vice-president of ITT has been transferred to its Executive Dept., while **John Thomas Naylor** has been elected a vice-president, succeeding Le Baron as director of the company's telephone and radio communications companies. **Harry Altman** becomes executive engineer at ITT Labs.

**William J. Flanagan** has been named director of material at Pacific Automation Products, Inc.

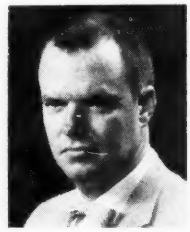
**Col. Daniel B. White** (USAF-Ret.) has been named assistant manager of eastern operations for Packard-Bell Electronics Corp.'s Technical Products Div.

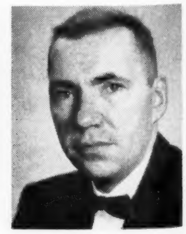

Konecci


Tenenbaum


Main

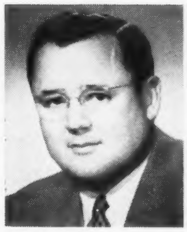

Rue


Mulready


King

Graham

Crowley



Wissemann

Lewis

**Dunstan Graham,** has been promoted from eastern operations manager of Lear's Grand Rapids (Mich.) Div., to head of the newly established Systems Management Office, Astronics Div., Santa Monica, Calif.

**James A. Montllor,** chief engineer, has been appointed vice-president of Essex Electronics.

**John P. Moffat Jr.,** former director of quality control, Electro Mechanical Instrument Div. of Consolidated Electrodynamics Corp., has been upped to the new position of chief engineer; **Edward P. Fleischer,** former manager of CEC systems and procedures, has been named assistant to the president; and **Frederick W. Schaar,** former field engineer, Washington, D.C. office, has been made manager of the Orlando, Fla., district office.

**Col. Benjamin G. Holzman,** commander of the AF Office of Scientific Research has been promoted to Brigadier General.

**John G. Meitner** has joined Hughes Aircraft as head of the analysis and research section in the Launchers and Power Plants Dept. of the company's guided missile labs.

NASA has appointed **James Patrick Gleason,** administrative assistant to former Sen. William F. Knowland, assistant administrator for Congressional relations.

**John O. Crowley,** director of the Guided Missiles Office of the Assistant Secretary of Defense for Engineering from 1954–57, has been appointed vice-president in charge of project management at Grand Central Rocket Co., while **H. L. Thackwell Jr.,** former senior vice-president in charge of project management and marketing, has been named to organize a new division for advanced planning on outer space flight vehicles.

**George B. Rathmann** has been promoted to project manager of the ARPA contract for solid propellant research at Minnesota Mining & Mfg. Co.

**Richard S. Boutelle,** former president of Fairchild Engine and Airplane Corp., has been elected vice-chairman of the board. **J. H. Carmichael,** who succeeded Boutelle, was also elected to the board.

**H. J. Wissemann,** assistant vice-president-engineering, Texas Instruments Apparatus Div., has been appointed general manager of the division. **E. O. Vetter,** general manager of the Industrial Instrumentation Div., has been elected as assistant vice-president of TI. **Cecil Dotson** has been elected board chairman of Texas Instruments Ltd., Dallas, Tex.

**Raymond C. Blaylock** and **Gifford K. Johnson,** vice-presidents of engineering and production, respectively, have been elected board members of Chance Vought Aircraft, Inc.

**James B. Fisk,** executive vice-president of Bell Telephone Laboratories has been elected as president, succeeding **Mervin J. Kelley,** who has been elected board chairman. **Estill I. Green,** vice-president in charge of systems engineering has been named executive vice-president.

Wyle Laboratories merges with Wyle Research Corp. into Wyle Laboratories, as of Jan. 5, with **Frank S. Wyle** continuing as president. **Clarence H. Wyle,** president of WRC, becomes treasurer. **Robert J. Garon** becomes vice-president, contracts; **David D. Stone,** assistant vice-president, contracts; **Robert S. Gardner,** vice-president, engineering and production; **Edward Rubin,** a vice-president; and **Alvin Samuels,** secretary. **Elmer R. Easton,** general manager, has also been named vice-president of Wyle Associates, engineering liaison agency for Wyle Labs. **James A. Sneller** has been named vice-president in charge of operations of Wyle Mfg. Co.

**Ronald M. Macdonnell,** deputy undersecretary of the Canadian Dept. of External Affairs, has been appointed secretary general of the International Civil Aviation Organization for a five-year term, effective next June.

**Edward P. Curtis,** executive vice-president of the Eastman Kodak Co., has been appointed general chairman of the first World Congress of Flight.

**Lt. Gen. C. B. Ferenbaugh** (USA-Ret.) has been appointed staff assistant to the president of United States Chemical Milling Corp.

**Robert E. Lewis** has been elected president of Sylvania Electric Products. He formerly was a senior vice-president of the company.

**John L. Gergen** has been named director of the Atmospheric Physics Div. of G. T. Schjeldahl Co.

**Edwin F. Clark,** former manufacturing staff assistant of the Marman Div. of Aeroquip Corp., has been promoted to manufacturing manager. **Robert W. Cooper** has been appointed chief production engineer.

**S. J. Colby** has been appointed assistant to E. P. Wheaton, vice-president-engineering, Douglas Aircraft's missiles and space systems program.

**Jack M. Cherne** has been named director of engineering for Vard, Inc.

**Maj. Gen. Oliver K. Niess** has been appointed Air Force Surgeon General, succeeding **Maj. Gen. Dan C. Ogle,** who retired last month.

**George Reichard,** chemical engineer, Redel, Inc., has been promoted to chemical staff assistant to vice-president Douglas C. Vest.

Beckman Instruments, Inc., has appointed **Max D. Liston,** director of engineering; **Thomas V. Parke,** director of product standards; and **Earl C. Janson,** director of manufacturing. **Stanley Schneider,** former chief research engineer of the Helipot Div., has been promoted to manager of engineering.

**Thurman C. Erickson,** former engineering manager, Servomechanisms, Inc., Subsystems Div., has been appointed assistant division manager, while **J. H. Reid,** formerly in charge of electronic systems predesign at Convair, has been appointed chief engineer.

**Ralph A. Burton,** associate professor of mechanical engineering at the Univ. of Missouri, has joined Southwest Research Institute as a senior research engineer for the Department of Engines, Fuels and Lubricants.

**Joseph Meisler,** has been named technical commercial manager, Philips Electronics Cryogenics Dept.

**Fred H. Rohde,** has joined Ratigan Electronics, Inc., as director of engineering; **Winston Key** becomes director of sales; and **William Croft,** former project manager, Sylvania, has been assigned to Rohde's technical staff.

**Roderic M. Scott,** vice-president of

Perkin-Elmer Corp., has been named to direct development of photo reconnaissance equipment for the Engineering and Optical Div.

**John M. Pearce,** former vice-president and general manager, Hoover Electronics Co., has been appointed to the new post of corporate manager of electronics requirements for The Martin Co.

## HONORS

**Maj. Gen. John B. Medaris,** Commander, Army Ordnance Missile Command; **Wernher von Braun,** ABMA; **Louis G. Dunn,** president, Space Technology Laboratories; and **Maj. Gen. Bernard A. Schriever,** Commander, AF Ballistic Missile Div., have been honored with National Technology Awards from the New York Institute of Technology.

**Louis F. Polk,** vice-president and group executive of Bendix Aviation Corp., and president of The Sheffield Corp., has been elected president of the American Ordnance Association. **Wilmer L. Barrow,** vice-president, R&D, of Sperry Gyroscope Co., becomes chairman of AOA's Fire Control Instrument Div.

**Robert D. Vaughn,** chemical engineer at Shell Development Co.'s Emeryville Research Center, is a cowinner of the 1958 Junior Award of the American Institute of Chemical Engineers, given to encourage excellence in contributions to A.I.Ch.E. publications. Other winners are **A. B. Metzner,** associate professor at the Univ. of Delaware, and **George L. Houghton** of Socony Mobil Oil Co.'s N.J. research labs.

**Charles S. Rockwell,** president of Ford Instrument Co., has accepted, on behalf of Ford Instrument, an "Oscar" of the missile industry for outstanding service for ABMA and the Army Ordnance Missile Command.

## DEATHS

**Hans R. Friedrich, assistant chief engineer for development of Convair-Astronautics and President of the ARS San Diego Section, who, as noted in January ASTRONAUTICS, died recently of a heart ailment in San Diego.**


DETECTION
LMED'S airborne GENDARME* will illuminate the unknown


Airborne Detection
in search
of time
GENERAL ELECTRIC

## Biodynamics of Space Flight

(CONTINUED FROM PAGE 24)

of rotation. Another is our inability to reduce the acceleration suddenly and to coast in the manner of a rocket at burnout.

The velocity required to maintain a vehicle in a stable orbit around the earth will vary with distance from the earth; but for reference purposes, let us say that 5 mps, or 18,000 mph, would be required for one of the relatively low-altitude orbits. To attain this velocity the rocket must accelerate for a g-time product of about 13.7 g-minutes, ignoring, for the moment, the pull of gravity and the effect of the earth's rotation. At present this is accomplished by two- or three-stage rockets giving a sawtooth acceleration profile, with peaks which vary in amplitude with different systems, but usually do not exceed 8 g with the total duration of thrust lasting 4 to 5 min.

When a vehicle traveling in orbit, say, 5 mps, re-enters the atmosphere to land on earth, it must decelerate the same number of g-minutes as was required to put it into orbit in the first place. Some slowing can be achieved by retro-rockets, but the major slowing will come from frictional resistance of the atmosphere. If the vehicle follows a ballistic trajectory with very little lift, the deceleration will all come in one stage.

The critical factor here is the angle of re-entry. Maximum deceleration rate will be very great if the re-entry path is a steep one; and although the duration may be quite short, it will exceed the tolerance of man. By making the angle of re-entry shallow, it is possible to trade-off magnitude for duration, and thus keep acceleration within tolerable range. If the vehicle is a high-lift, low-drag shape, it is possible to keep the maximum g quite low by very gradual re-entry or even to stage the deceleration by dipping into the atmosphere and pulling up repeatedly. This would involve shifting acceleration vectors, so that a forward-facing seated subject would be thrown alternately forward and downward, but the forces would be small. The top figure on page 25 shows a typical acceleration profile of a boost into orbit and return to earth.

How well can man tolerate 13.7 g-minutes? The g-time product he can stand varies tremendously with the magnitude of acceleration and with the position of his body in relation to the acceleration vector. The bottom figure on page 25 summarizes graphically the influence of body position and the magnitude of acceleration on the tolerance of man expressed in g-minutes.

When a man is accelerated headward (the traditional positive acceleration), the inertial effect tends to displace every part of his body footward. The physiological limit to acceleration in this position is caused by difficulties in the circulation of blood. The inertial effect opposes the arterial flow of blood from the heart to the head and the flow of blood in the veins back to the heart from the lower parts of the body. Although there are compensatory constrictions of blood vessels and an increase in the rate of heart beat, the circulation to the head is progressively impaired with increased acceleration. The first effect of this is a dimming of vision, then visual failure (blackout) and finally unconsciousness, perhaps with convulsions as the brain is deprived of blood.

### Blackout Level

The g-level at which blackout occurs varies with the rate of increase of acceleration, with the light intensity and with the psychophysiological state of the individual, among other things. In general, we can say that blackout occurs in less than a minute at 4 to 6 g and that there is a high probability that a subject riding a rocket vehicle into space head first would lose vision and perhaps consciousness during the boost phase. If he wore an anti-g suit to compress the lower part of his body, he could add another g-minute or so to his tolerance, but he would still be vulnerable in most rocket profiles.

The footward, or caudad acceleration vector (traditionally known as negative g), we mention only to dismiss as unsuitable. The inertial effect exerted on the blood in the longitudinally arranged great blood vessels causes a painful congestion in the head. Small unsupported blood vessels around the eyes and in the nasal and sinus areas may leak blood. The circulation to the brain is protected in that it is in a water-filled rigid container, but the voluntary tolerance to acceleration in this cauded direction is limited by the other factors mentioned, being less than half a minute at 2 g and only a few seconds at higher levels.

The body positions most favorable to resisting the effects of acceleration are those in which the g-vector is across one of the transverse axes of the body. The inertial effect is across the columns of blood in the large blood vessels so that gross effects on the circulation do not appear so readily as they do when the vector is

parallel to the long, longitudinal vessels of the body.

The principle limiting factor in transverse g is respiratory. Above 6 g it is difficult to inspire, so that the duration of tolerance at higher levels is largely limited to the breathholding time, which is shortened under conditions of acceleration by the involuntary increase in muscle activity (including cardiac muscle) which occurs in this situation.

In addition to the handicap to respiration there are certain painful stimuli probably caused by traction on sensitive membranes due to the shift of certain body parts. A prime example is the movement of the relatively heavy heart in the air-filled chest.

Apparently most suitable for tolerating the accelerations anticipated in the boost phase of rocket flight is a seated, forward-facing position with the trunk inclined forward and with the knees flexed. The optimal degree of forward inclination has not been determined. A number of considerations influence this. It has been found that chest pain from the upright, seated position at 6 to 8 g was relieved by leaning forward 25 deg.

On the other hand, a subject in this position wearing a complete pressure suit suffers a handicap in this abdominal respiration, which is particularly important in transverse-g tolerance. Further, the more a subject leans forward, the more vulnerable he becomes to visual failure, characteristic of headward acceleration.

The positioning of the legs has an influence on g-tolerance in this position. When the legs are flexed at the hip, there is some gain in tolerance, presumably by virtue of the blood displaced from the legs to the trunk; but if the lower legs are extended forward, their circulation is impaired, with disappearance of pulse in the lower leg arteries, and the subject feels pain.

If the forward accelerating subject is inclined backward, he becomes vulnerable to the congestion of the head characteristic of footward acceleration.

#### Restraints

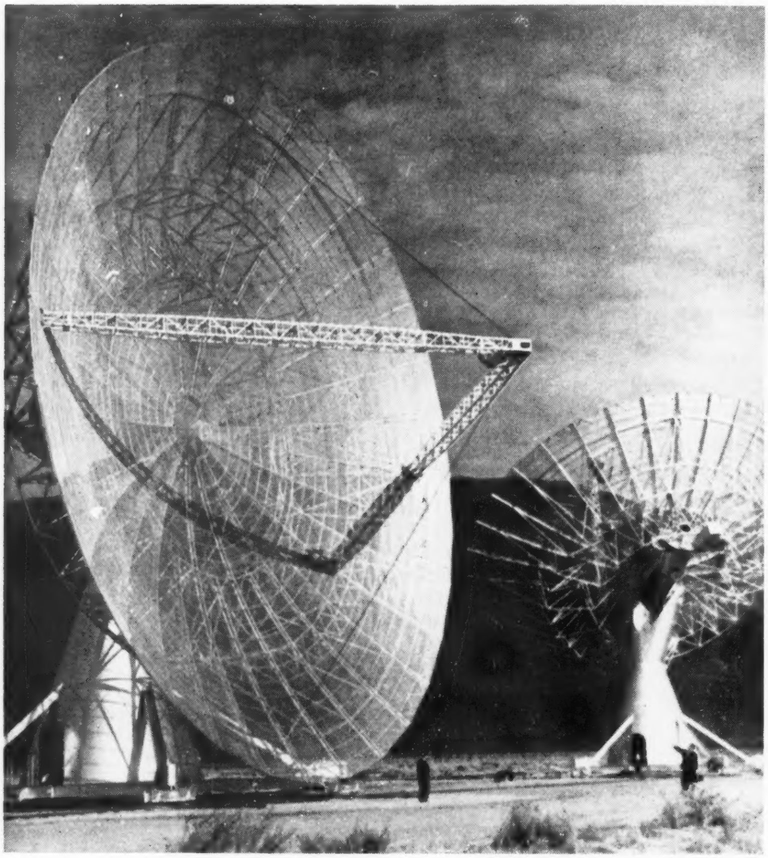
Backward acceleration tolerances may be important for re-entry. The chief factor in determining tolerance in this position is the restraint system. Unlike forward acceleration, where little special restraint is needed, since the subject is pressed back into his seat, backward acceleration tends to throw the subject from his seat. Restraints in current use are totally inadequate in backward acceleration because they do not prevent the subject from slipping out of position and because of painful and constrictive pressure effects. With a restraint suit distributing the inertial force over wide surfaces, and with multiple tie-down points, combined with good head restraint, the tolerance to backward acceleration of a man seated upright closely approaches that of forward acceleration.

This means that it may not be necessary to turn the seat of a space capsule around for re-entry into the atmosphere. Here again, the flexion of the knees is important, because in the backward position extended legs become painfully congested.

The lateral-transverse position has not been studied as completely as the anterior-posterior transverse vector, but tolerance appears to be of a similar order. However, X-rays of subjects accelerated laterally show a remarkable shift of some viscera to the opposite side, particularly the heart, liver, and stomach, as well as the blood in the lungs.

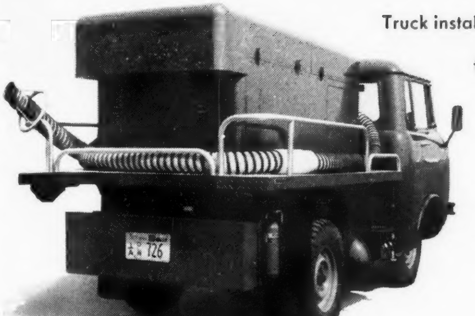
In addition to the g-patterns indicated in the top figure on page 25, there may be situations in which human tolerance limits, as established with volunteers on large centrifuges, are exceeded. These include emergency escape in the boost phase, aerodynamic instability in either boost or re-entry, and too abrupt patterns of re-entry. The effect of these situations cannot be accurately predicted now. The end-points used to calibrate human tolerance to acceleration are largely subjective and vary from one body position to another. In general they are drawn at the point where it is felt that the capacity of the subject to perform effectively is impaired, which, in this day of pushbutton controls, means the capacity for intelligent observation and decision.

With this conservative approach,



## Listening to the Stars

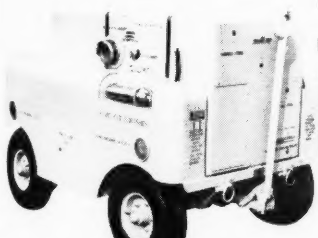
**These two 90-ft diam twin antennas, under construction by the Navy and CalTech at Big Pine, Calif., will be used to listen to radio sounds coming from stars and other objects in outer space. Their range may exceed that of the 200-in. telescope at Palomar.**



Truck installations supply pneumatic power for main engine starting, cooling and heating, electrical power for commercial jet powered airliners.

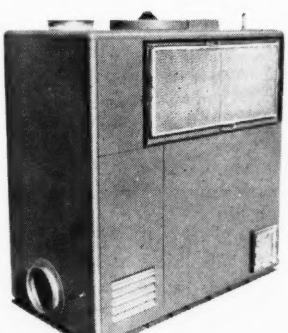
Dual carts for main engine starting, air conditioning and electrical power for military aircraft.

# Reliable and versatile ground support



AiResearch MA-1A trailer for starting military aircraft. Nearly 2,500 in the field.

Air transportable pod for engine starting, cooling of electronic equipment and pre-flight checkout for military aircraft.



Lightweight Freon system, usually installed in a van or trailer, for cooling electronic equipment in support of missiles.

***AiResearch ground support equipment is tailored to meet turbine powered aircraft and tactical missile requirements. Lightweight, compact units can be designed to specific configurations or installed on standard vehicles.***

Heart of the lightweight ground support systems are AiResearch gas turbine compressor power units. Capable of delivering both electrical and pneumatic power, nearly 8,000 of these units are operating successfully and dependably in the field.

Support services can include: main engine starting, pressurization and air conditioning of cabins and compartments, missile pre-flight check-out, removal of snow and ice from aircraft and equipment, supply of DC or AC electrical power at any required frequency, and low pressure, high flow air for operation of a variety of actuation systems. The units have push-button starting and operate without delay under all weather conditions.

The world's largest producer of lightweight turbomachinery, the AiResearch Manufacturing Divisions are prepared to assume complete systems management responsibility for your ground support requirements.

ENGINEERING REPRESENTATIVES: AIRSUPPLY AND AERO ENGINEERING, OFFICES IN MAJOR CITIES

**THE GARRETT CORPORATION**

**AiResearch Manufacturing Divisions**

*Los Angeles 45, California • Phoenix, Arizona*

*Systems, Packages and Components for:* AIRCRAFT, MISSILE, ELECTRONIC, NUCLEAR AND INDUSTRIAL APPLICATIONS

we cannot titrate the limits of reversible injury or survival. Consequently, for evaluating the possibilities of high or complex acceleration patterns in emergency situations, we only have data from animal experiments and scattered information from accident reports on which to base our judgment. With regard to high-g effects, it has been reported that chimpanzees survived 40 g transversely applied either backward or forward for 60 sec.

Human subjects exposed to rotation about a transverse body axis tend to have their blood centrifuged toward the two ends of the body. This results in circulatory difficulties, varying from the effects of congestion to unconsciousness, according to the rate of rotation and the center of gravity. It has been estimated that unconsciousness would occur at 160 to 180 rpm. Little is known about the effects of rotation about the verticle axis except from the experience of circus performers, ice skaters, etc. The tolerance of man to oscillatory accelerations is currently under investigation.

As we have already indicated, the primary protective measures have to do with body positioning and, in general, involve keeping the hydrostatic columns of blood parallel to the accelerative vector as short as possible. Counter pressures can be used to minimize hydrostatic effects. We have mentioned the importance of restraint on backward acceleration. It is probable that a form-fitting support would be of value in all acceleration vectors.

### Ideal Protection

The ideal protection would appear to be complete immersion in a rigid water-filled container, in which the buoyancy of the body effectively counteracts its weight. Indeed, the highest tolerances in terms of g-minutes have been demonstrated using this principle. However, respiration is still a limiting factor, and shifts of viscera due to variations in their specific gravity from the surrounding medium are not prevented by immersion in water. This is particularly true of the air-surrounded heart. A notable disadvantage of such a system would be its great weight. Theoretically, the quantity of water could be greatly reduced by making the rigid container closely correspond to the body of the subject; but, unfortunately, this would also reduce the mobility of the subject, which is one of the great advantages from water immersion.

Finally, we have the problem of pilot performance when under acceleration stress. The first consideration, in regard to performance, is that with acceleration there is diminished capacity for whole limb and body movements as the weights of body parts are multiplied by acceleration. This handicap increases with the addition of bulky personal equipment. It makes necessary arrangement of controls so that they can be operated with fingers and wrists and displays which are visible without body movement.

The capacity of a man to perform several tasks while undergoing a three-stage acceleration typical of rocket boost into orbit has been measured. Although there was some deterioration of his performance, it was felt that a man could be expected to assist in the control of such a vehicle during the launching phase. Other workers have indicated that there is little decrement in performance at relatively low accelerations. There is still need, however, to measure the capacity of a man to observe, make decisions, and react during high, sustained, and repeated accelerations.

## Capsule for Man in Space

(CONTINUED FROM PAGE 30)

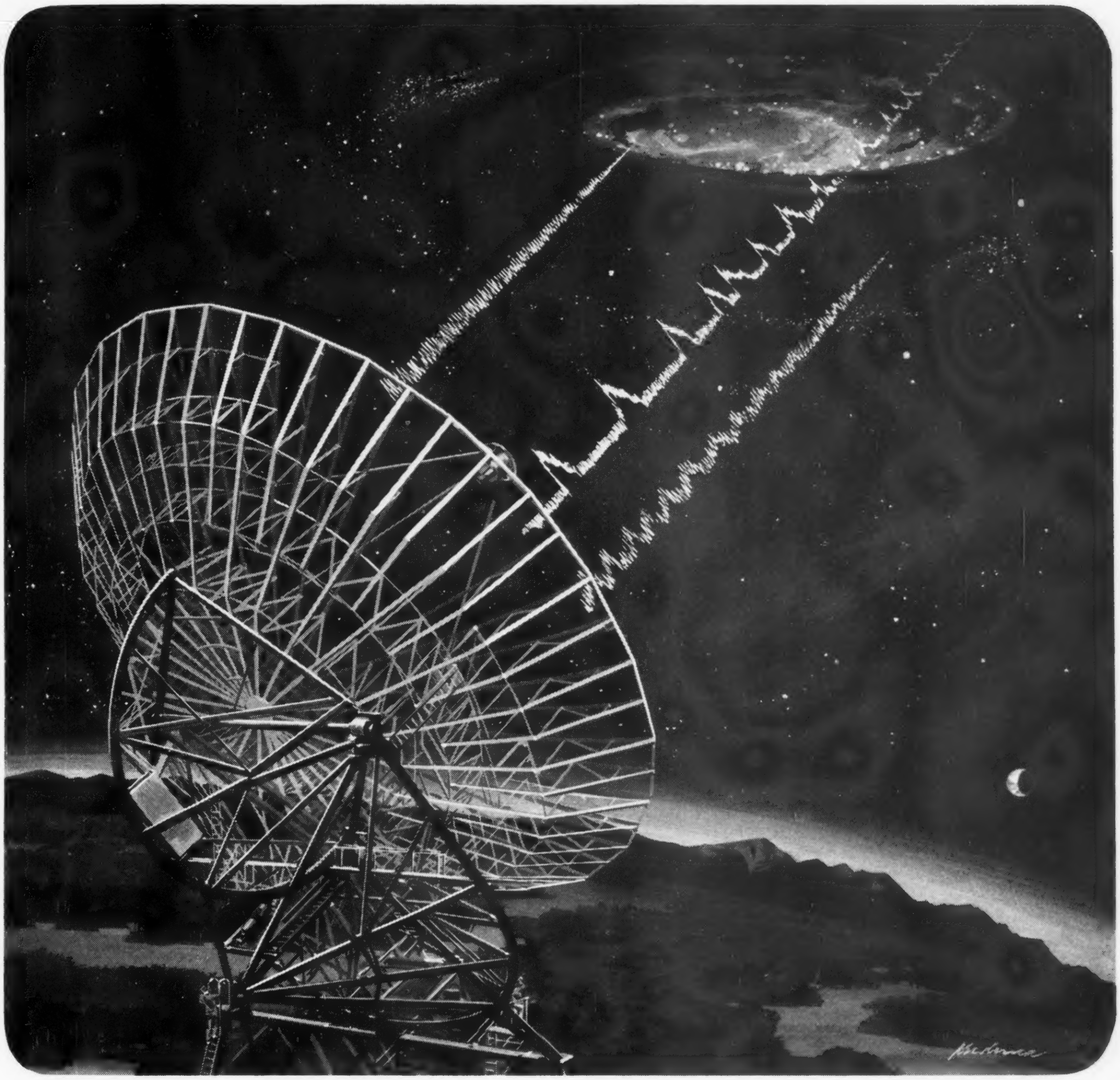
techniques, approaches and technologies would be employed.

"A stringent program of qualification and reliability testing will be conducted prior to the first launch of man into orbit," he commented. "The preflight test program, with drop tests, impact tests, environmental tests, and many others, will be more stringent than on any program of the past or present.

"Early ballistic nonorbiting flights, unmanned and with small animal life, will be made to prove out the entire system. Initial flights into orbit probably will be with complete, but unmanned, satellite systems. All this effort is directed to achieve maximum reliability and safety."

Paige pointed to the proposed NASA satellite design, on page 30, as an example of the attention being given to safety of the occupant. He noted that a dual parachute system, with one backing up the other, has been added to the basic vehicle to assure safe final descent, while the new forward pylon structure would house the escape rocket used to get the capsule out of the vicinity of the booster in the event of a failure during launch.

The photo on page 30 shows the interior of one of the GE capsules. This capsule may be compared with early NASA design ideas, shown on page 45 of September ASTRONAUTICS. It clearly capitalizes on the successful nose cone the company developed for



# *How a creative engineer can grow with IBM*

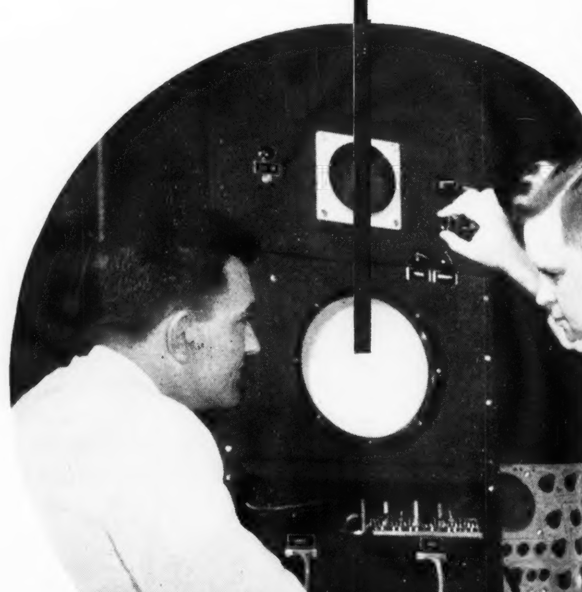
"Certainly my present assignment on the B-70 offers many growth opportunities," says Project Engineer Edward V. Zaucha. Designed to fly farther, faster and higher than any manned aircraft ever has before, the B-70 requires a completely new radar display system. "My responsibility includes the design of new cathode ray tube circuits plus system studies dealing with specific bomb-nav problems. These studies cover related equipment, such as the search radar and circuit indicator devices. In addition, I coordinate the development of storage tubes, high voltage power supplies and other equipment. A job that covers this much territory is a creative challenge. With IBM I have the opportunity to use all of my training; and in addition, I learn new things every day that will advance my engineering career."

## *Career opportunities in these areas...*

- **Airborne digital & analog computers**
- **Ground support equipment**
- **Inertial guidance & missile systems**
- **Information and network theory**
- **Magnetic engineering**
- **Maintainability engineering**
- **Optics**
- **Radar electronics & systems**
- **Servomechanism design & analysis**
- **Theoretical design & analysis**
- **Transistor circuits**

**Qualifications:** B.S., M.S. or Ph.D. in Electrical or Mechanical Engineering, Physics, or Mathematics, and proven ability to assume a high degree of technical responsibility in your sphere of interest.

IBM is a recognized leader in the rapidly expanding electronic computer field. Its products are used for both commercial and military applications. Continuous growth means excellent advancement opportunities. The "small-group" approach assures recognition of individual merit. IBM provides excellent company benefits and salaries are commensurate with your abilities and experience.



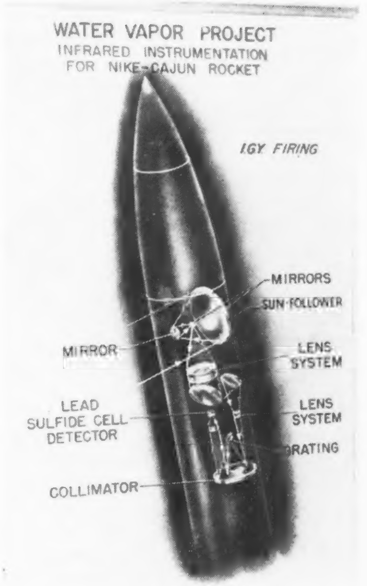
the Thor and Atlas missiles, and utilizes data based on acceleration tests, putting the occupant in a seat molded to his body and inclined forward at an angle of about 65 deg.

As this is written, NASA is reviewing bids from the following firms for development of a 1-ton space capsule capable of orbiting earth for periods up to 28 hr:

Grumman Aircraft, Bethpage, N.Y.; Chance Vought Aircraft, Dallas; Convair Astronautics, San Diego; Avco Mfg. Corp., New York; Douglas Aircraft Co., Santa Monica, Calif.; North American Aviation, Los Angeles; McDonnell Aircraft, St. Louis; Northrop Aircraft, Beverly Hills, Calif.; The Martin Co., Denver; Republic Aviation, Farmingdale, N.Y.; Lockheed Aircraft, Burbank, Calif.; and Winzen Laboratories, Minneapolis.

By the time this issue reaches you, work on the first vehicle to take man into space should be well under way.

## Lead Sulfide Cell Is Heart Of New Hygrometer




A photosensitive lead sulfide cell, which has an electrical reactivity directly proportional to the intensity of sunlight or radiation beamed on it, has been installed in the nose of Nike-Cajuns to measure humidity at 100 km. The cell is the heart of a new Lead Industries hygrometer. In addition, the instrument, pictured above, consists of an optical system which stabilizes the instrumentation with respect to the sun; grating to filter the sun's light as to wavelength; and a collimator, to focus reflected light on the cell.

## International Scene

(CONTINUED FROM PAGE 9)

was founded in December 1957, by a group of astronomers, technicians, and professors from Athens technical colleges and Athens Univ. When the society was admitted to membership in the IAF in August 1958, it had 47 members. The delegation which attended the Ninth IAF Congress was composed of the president, Stavros Plakidis, professor of astronomy and director of the Athens National Observatory; the vice-president, Gen. Constantine Exarchakos, Army of the Air; and the general secretary, Elie Petropoulos, of the Ministry of Communications and Public Works.

° ° °

Professors at the Hebrew Univ. in Jerusalem formed the nucleus of the *Israel Astronautical Society*, organized in July 1958. Prof. Abraham H. Fraenkel of the university represented the society at last year's IAF Congress, and during the course of the Congress the society became a member of IAF. Prof. Shmuel Sambursky of the University's Physics Dept. is president. In addition to members from Hebrew Univ., there are members from the Scientific Dept. of the Ministry of Defense and from the Israel Institute of Technology in Haifa.

° ° °

The *Japanese Rocket Society* is the second Japanese astronautical society to become an IAF member, the first being the Japan Astronautical Society. The new society was formed in the summer of 1958, and was admitted to membership during the Amsterdam Congress. The officers are: President, Hideo Itokawa; executive secretaries, Takeo Omori and Seiichiro Nozawa; secretary, Kayoko Kataoka; treasurers, Sukenori Yamamoto and Yoshichiro Shimizu.

° ° °

At the Ninth IAF Congress, India was represented by L. J. Carter, secretary of the British Interplanetary Society. During the year, a good deal of correspondence was undertaken in connection with the formation of an Indian Astronautical Society. The writer has been advised by the Registrar of the Univ. of Bombay that the Syndicate of the University, on the recommendation of the Board of Studies in Physics, are in favor of the formation of an Indian society. S. C. Sen, principal of the Delhi Polytechnic Institute, referred the writer to the Indian Aeronautical Society, the Indian Science Congress, and the National Institute of Science of India. One of the most enthusiastic proponents of astronautics in India is D. R. Bhawalkar, head of the Physics Dept. of the Univ. of Saugar. It is believed that in time an excellent Indian society will be organized.

While still in Asia, it should be noted that H. K. Afshar, director of the Tehran Univ. Geophysical Observatory, Tehran, Iran, attended the Ninth Congress and received observer status. He reports that an Iranian Astronautics Society is in process of formation.

° ° °

Returning to Europe, we find that under the direction of R. Peschek of the Technical Univ. of Prague, an astronautics society is being formed within the framework of the Czechoslovak Academy of Sciences. Prof. Peschek was an observer delegate to the last Congress. Similarly, within the Hungarian Academy of Sciences there is being formed a Hungarian Astronautical Society under the leadership of Erno Nagy and Jozsef Sinka.

Under the leadership of General Fuat Ulug, chief of scientific consultation and development of Turkey, a committee is working on the formation of an astronautics society within the framework of the Turkish Astronomical Society. General secretary of the committee is Saadettin Topuzoglu of the Turkish Astronomical Society.

In Portugal, A. Varela Cid of the Technical Univ. of Lisbon has organized an excellent group and the Portuguese Astronautics Society is already under way.

In Ireland Prof. E. J. Öpik of the Armagh Observatory is making sincere efforts to organize an astronautics society. He has received heartening assistance from scientists throughout Ireland. His work may be delayed, however, because he is now on leave of absence at the Univ. of Maryland.

## "Megaboom" Tests Pilot Protection

**This one-piece pilot-protection suit with fiberglass helmet, under study at the AF Missile Development Center, allowed the enclosed dummy to survive a boost to 1200 mph in less than 8 sec in a sled run on the Holloman track, a speed which produced a wind blast of 4000 lb/sq ft. The Astrodyne solid propellant motor, "Megaboom," which powered the sled in the test, had been stored for 18 months yet delivered its full-rated thrust and normal burning performance.**

## King-Size Fuel Tank

**Final welds are put on a battleship tank, with capacity of 9300 gal, that Rocketdyne will use as a fuel reservoir for rocket engines.**

---

### Soviet Biological Experiments

(CONTINUED FROM PAGE 31)

gations of the effect of space flight on human organisms have been going on since 1949. In the initial phase of the experiments, rockets flew encapsulated animals to heights of 100–210 km (62–130 mi), and then ejected them for return to Earth by parachute.

Animals were encapsulated in specially equipped, hermetically sealed cabins supplied with an air-conditioning system which permitted keeping gas composition of the air, temperature, and humidity at levels making possible normal activity of the organism under study. The air-conditioning system was designed for two days but needed to operate only the three hours during which animals were under observation.

Instrumentation provided data on the animals' breathing, blood pressure, biological electric currents, and temperature before launch, in rocket flight, and in parachuting back to Earth, as well as changes in cabin pressure and temperature, and acceleration, he noted.

No major changes were observed in the animals that could be regarded as resulting from acceleration either on launching or when the parachute reached the dense air layers. The effect of 3–6 min of weightlessness was almost imperceptible. Animals sent aloft twice showed no perceptible changes in behavior or general condition either immediately after the flight nor any time thereafter.

The next phase of the experiments called for elimination of the capsule, catapult separation of an animal from the rocket during its descent and subsequent descent of the animal in a special high-altitude suit with the help of a parachute.

A good deal of attention was given to protecting the animals during the rocket's descent trajectory, when its flight was not fully stabilized. Two types of catapult experiments were carried out. In one, the catapult apparatus was started at a height of 75–85 km (47–53 miles), with the parachute opening immediately and the animal's descent taking more than an hour. In the other, catapulting was effected at 39–46 km (128,000–151,000 ft), the parachute opening at a height of only 4 km (13,000 ft.).

These experiments, too, proved successful, Dr. Kousnetzov noted, with neither catapult launching nor parachute descent detrimental to the animals' health or lives.

The third phase of the experiments began last year, culminating in animal rocket launchings to a height of 473 km (294 miles). Animals also returned from these high-altitude flights in good health.

#### Laika Experiment

The rocket experiments permitted extensive study of various effects on living organisms in the upper air layers. However, Sputnik II, which carried Laika, made possible a biological experiment meeting all the conditions of space flight.

Of particular interest in the experiment was the state and behavior of Laika at the most crucial moments of flight—the period from launching to the time the satellite was placed in orbit. During this period, the animal was in such a position as to sustain transverse acceleration, and data about the condition and behavior of the animal were successfully transmitted and received for this period.

The data showed that the frequency of heart contractions rose to three times the initial frequency. Electrocardiogram analysis showed no serious changes in the workings of the heart, and later, despite the growing effect of acceleration, the frequency of heart contractions decreased. The animal's respiratory rate was also three to four times higher than the initial rate during this period.

The Soviet expert explained there was every reason to believe that changes noted in the animal's physiological functions were brought about by the sudden onset of external irritants—acceleration, noise, and vibration—which began at launching and continued until the satellite was orbiting.

A comparison of data from Sputnik II and from previous lab experiments led to the conclusion that Laika's condition had been satisfactory from launch to orbit.

The effect of the zero-g condition on the animal was also studied carefully. With the onset of weightlessness, Laika made small bounds on the floor because of contraction of the muscles of the limbs. The data indicated these movements were smooth and of short duration.

After a brief period, the rate of heart contractions fell, almost reaching the initial rate. However, it was observed that the period of time necessary to reach the original rate was about three times as long as in lab experiments in which Laika was subjected to the same acceleration as that of the satellite launching vehicle.

This, Dr. Kousnetzov explained, was probably due to the fact that, in lab experiments, the animal found itself in a normal condition after acceleration ceased, while in the Sputnik, acceleration was followed by weightlessness. The absence of signals from receptive organs as to the position of the body in space, he believes, caused a change in the functional state of the nervous system regulating blood circulation and breathing, and led to delay in the return to normal of these functions. This phenomenon may have been aggravated as well by accompanying factors such as noise and vibration, their intensity being greater in the actual launching than in the lab experiments, he added.

Changes in the animal's physiological functions recorded during this period generally coincide with the results of the previous high-altitude rocket experiments, Dr. Kousnetzov commented.

Analysis of the electrocardiogram

during the zero-g state showed some changes in the configuration of its elements and the duration of its intervals. These changes were in no way pathological, he pointed out, and were brought about by the increased functional load at the moment preceding the zero-g condition. The ECG showed alterations in the reflex and nervous character of the work of the heart. At a later stage, it showed a closer and closer resemblance to the ECG characterizing the animal's initial condition.

Despite the absence of gravity, Laika's motor movements were moderate. Return to normal of blood circulation and breathing during the zero-g state when the satellite was orbiting seems to indicate that weightlessness resulted in no major changes nor any stable changes in the animal's physiological functions, he noted. In other words, the animal got on satisfactorily both during the period when the satellite was going into orbit and when it was actually orbiting.

Finally, Dr. Kousnetzov stated that it was impossible to arrive at a final conclusion as to the effect of cosmic radiation on the animal since no direct indication of physiological influence was discovered.

However, he added, the results of the experiment must be regarded as encouraging for future research geared to protect the life and well-being of man in space.

**U.S.S.R. R&D**

While a good deal of this information had reached print long before the Louvain meeting, Dr. Kousnetzov's paper does represent one of the best rundowns on this subject available to date. What else the Russians are doing remains a secret hidden behind the Iron Curtain, but certainly some conclusions can be drawn.

In view of the fact that the Russians have already designed and built a workable space capsule which (apparently) has kept an animal alive in space for a considerable period of time; that animals have been sent on rocket flights (and successfully recovered) to altitudes considerably higher than those reached in similar U.S. experiments; and that Soviet scientists have indicated full awareness that the next great step in astronautics will consist of sending a man into space—there can be little doubt that the U.S.S.R. program is at least as far advanced as our own, and perhaps a little ahead.

Who wins the race is likely to be determined by how much effort goes into such programs in the next 12 to 18 months.

# In print

**Rocketry and Space Exploration** by Andrew G. Haley, D. Van Nostrand Co., Princeton, N. J., 1958, 334 + xv pp., illus. $6.75.

In an era when fat volumes on rocketry and astronautics are counted in the dozens, it is refreshing to come across a work with a point of view. This splendid new book by Andrew G. Haley falls into that category. It is not just another book on this subject. Rather, it is a book largely devoted to coverage of areas which have been overlooked or neglected by other authors working in this field.

These areas are, naturally, those in which the author is particularly interested—the burgeoning rocket industry (Mr. Haley was one of the founders of Aerojet Engineering Co.,); space law (he was one of the first lawyers to concern himself with the legal problems arising out of upper atmosphere and space exploration); and international cooperation in the field of astronautics (he is now president of the IAF).

In concentrating on these areas, the author does not neglect other subjects—the history of rocketry, how rockets operate, allied and axis war rockets, etc. However, where most authors devote chapter after chapter to such subjects, Mr. Haley provides a few pages which tell the story briefly but succinctly. In fact, the first chapter, on what might be called rocket pre-history, adorned with some excellent drawings, is about the finest short account available anywhere.

However, it is in the chapters dealing with post-war rocketry, the rocket industry, and the international picture that the author really shines. Available here for the first time, for example, is the complete history of the IAF, the story of the founding and growth of many of the major companies in the field, of important developments, and of people responsible for them.

Mr. Haley's rundown of the working societies in the field of rocketry and astronautics (the first of its kind) is invaluable, as is his account of rocketry in Great Britain, France, Switzerland, and other foreign countries. The chapter on Russian activities is short and to the point, steering clear of speculation and concentrating on what is generally accepted as factual.

This review would be incomplete without mention of the more than 170 excellent photos the book contains. These form almost a complete picture history of rocketry, and include a number of hitherto unpublished pictures of the early Goddard and ARS experiments, as well as a long list of missile photos and photos of many of the leading figures in the field.

The publisher is deserving of a word of praise, as well as blame, for the book—praise for the large format, splendid photo reproduction and handsome appearance; blame for the generally poor editing and photo captions.

Every book is in the final analysis a reflection of the author. Nowhere is this more evident than in this book, born out of Andy Haley's long-term interest in rocketry and space flight, as well as a lifelong interest in people. It is deserving of a place in every library.

—Irwin Hersey

## BOOK NOTES

**Vistas in Astronautics,** edited by Morton Alperin, Marvin Stern and Harold Wooster (330 pages, Pergamon Press, New York, $15), presents 40 papers from the first Astronautics Symposium held in San Diego, Calif., in February, 1957, under joint sponsorship of AFOSR and Convair. The papers cover six major topics: Reentry, tracking and communications, environment and measurements, propulsion, orbits, and human factors.

Four papers make up a third of the book: "A Precise Attitude Control System for Artificial Satellites," by Hermann Oberth, parts of which appear in his book, "Man into Space"; "Deceleration and Heating of a Body Entering a Planetary Atmosphere from Space," by Carl Gazley Jr.; "Microlock," by Henry L. Richter, et al.; and a legal discussion of missiles and satellites by Andrew Haley.

These and a variety of brief and precise statements on such topics as the ballistic missile program, solar activity, propulsion schemes, optical tracking, space medicine, etc., answer the dual purpose of the symposium—to survey scientific and technological progress in astronautics and to indicate lines of research that will likely contribute to projects for exploring space.

**Handbook of Physics,** edited by E. U. Condon and Hugh Odishaw (1504 pages, McGraw-Hill, New York, $25), is a comprehensive guide to basic physics in the form of a condensed text, with subjects treated by scientists of recognized accomplishment. Major sections of the handbook

cover mathematics (including chapters on tensor calculus, calculus of variations and elements of probability), mechanics of particles and rigid bodies (contributed largely by Dr. Condon), mechanics of deformable bodies, electricity and magnetism, heat and thermodynamics, optics, and atomic, solid-state and nuclear physics. The text is supported by numerous carefully prepared tables, graphs, illustrations and references. The lists of references show a knowledgeable selection, being neither skimpy nor puffed up with secondary works.

This book shines with good editing, both of subject matter and detail. It should prove a valuable reference, especially for laboratories and technical libraries.

**Solid Propellant Rockets, Second Stage,** by Alfred J. Zaehringer (303 pages, American Rocket Co., Box 1112, Wyandotte, Mich., $8), is a re-issue, with five new chapters, of the handbook first published in 1955. Intended as a combination of introductory text and handbook, it covers historical development of solid rocketry and its current applications, as well as interior and exterior ballistics, propellant processing, static and free-flight testing and numerous minor topics, such as safety. It contains many graphs, illustrations, tables, and references.

**Missile Engineering Handbook,** by C. W. Besserer (600 pages, D. Van Nostrand, New York, 1958, $14.50), is the fourth volume in a series entitled "Principles of Guided Missile Design," edited by Grayson Merrill. Intended as a basic text for graduate engineers and technical officers of the Armed Forces, the book brings together information needed for broad design studies. The book is well illustrated and has a 182-page glossary.

**War and Peace in the Space Age,** by James M. Gavin (304 pages, Harper & Brothers, New York, $5), surveys the nation's military might and future. Gen. Gavin's views, having aroused controversy, will be of interest to anyone trying to shape an informed opinion of the impact of the cold war, the weapons built in the past 10 years and the ones to come in the next 10, and the effect of the military establishment on the course of national events. The book, unfortunately, seems to have been ghost-written and is often hackneyed, to the detriment of the author's intent.

## RECEIVED

**Russian-English Glossary of Guided Missile, Rocket and Satellite Terms,** compiled by Alexander Rosenberg (352 pages, Library of Congress, Washington, 1958, $2.50 from L. C. Card Division). An extensive reference for translators and researchers in paperbound 8 x 11 1/2 in. format.

**Welding Handbook—Gas, Arc and Resistance Welding Processes,** Section II of Fourth Edition (American Welding Society, New York, 1958, $9.00). Second volume in major welding reference; 13 chapters, each with bibliography.

**Engineering Consultants, 1958 Directory** (available from American Institute of Consulting Engineers, 33 West 39th St., New York 18, N.Y.; hard bound, $2.50, and paperbound, $1.50). Listings of qualified engineers, bibliographical information and information on services available.

**Air Intake Problems in Supersonic Propulsion,** edited by J. Fabri (82 pages, Pergamon Press, New York, $5). Invited papers from 1956 AGARD Combustion and Propulsion Panel, two in French and two in English (D. D. Wyatt and Antonio Ferri).

**A Study of Several Aerothermoelastic Problems of Aircraft Structures in High Speed Flight,** by John C. Houbolt (108 pages, Verlag Leeman, Zurich, Fr. 12.45). A monograph, paperbound.

**Application Of Atomic Engines in Aviation,** by G. N. Nesterenko, A. I. Sobolev and Yu. N. Sushkov (OTS, U.S. Dept. of Commerce, Wash. 25, D.C., $3). Translation of an illustrated Russian book published in 1957.

**Simplified Satellite Prediction from Modified Orbital Elements** (Publications Office, National Academy of Sciences, Wash. 25, D. C., $1) describes a method of prediction (prediction good for a week or more) requiring no computation more complicated than long division.

**Rockets and Missiles,** by Erik Bergaust (second printing, 48 pp., G. P. Putnam's Sons, New York, $2). Pictures and brief descriptions.

**Rockets Around the World,** by Erik Bergaust (48 pp., G. P. Putnam's Sons, New York, $2). Some foreign rockets described and pictured.

**G. O. Fizzickle Pogo,** by Walt Kelly (191 pp., Simon and Schuster, New York, $1). Pogo and friends shed new light on IGY.

**Guide to the Literature of Mathematics and Physics, Including Related Works of Engineering Science,** by Nathan Grier Parke III (436 pp., Dover Publications Inc., New York; $2.49). Paperbound; includes agencies and persons doing Russian translations.

**Aviation Medicine, An Annotated Bibliography,** Vol. 2—1953 Literature, by Arnold J. Jacobius, et al. (Available from the Aero Medical Assn., 2642 University Ave., St. Paul 14, Minn,; $5, postpaid in U.S. and Canada).

**The Atom and the Energy Revolution,** by Norman Landsdell (200 pp., Philosophical Library, 15 E. 40 St., New York 16; $6).

**Gravity and Interplanetary Travel,** by Max Goodrich (72 pp., Vantage Press, 120 W. 31 St., New York 1; $2.50). Some personal views of the author.

**Forgings, American Standard Y14.9-1958** (American Standards Assn., 70 E. 45 St., New York 17; $1.50).

**A Catalog of Devices Useful in Automatic Data Reduction:** Part 2, First Revision, by R. S. Hollitch and A. K. Hawkes, Illinois Institute of Tech. for WADC (Order PB 111928R for OTS, Dept. of Commerce, Washington 25, D.C.; $5).

## Weightlessness

(CONTINUED FROM PAGE 27)

in this strange condition without any preparation, as when awakening in the weightless state. Our last series of flight experiments in jet aircraft included just such an experiment. First Lt. C. M. McClure, who shortly afterwards served as pilot of the Manhigh III balloon flight, was selected as the subject. For this weightlessness experiment, he went without sleep for 48 hr. After a full breakfast, which increased his sleepiness, he entered the rear cockpit of our experimental F-94C. He unhooked his headset at 11,000 ft, so as not to be disturbed by the conversation among the pilot, tower, and experimenter. Some 25 min after takeoff, he fell asleep, leaning against the right side of the cockpit. A string was fixed on his left wrist, which the pilot could pull to awaken him. The pilot avoided any rough maneuvers. The aircraft was then flown in a zero-g trajectory and Lt. McClure was awakened.

### First Impressions

His first impression upon awakening was that his arms and legs "were floating away from him" so that he felt a desperate need to pull them back toward his body to maintain some sort of normal posture. He tried to hold on to the canopy and some part of the cockpit. He could not orient himself. All this, despite the fact that he is a pilot with over 500 jet hours in the air and never felt such pronounced disorientation before.

Lack of either orientation or coordination can be considered as originated by the weightless state per se. However, more complex problems arise in the transition phase from a one-g or multi-g field to weightlessness, and vice versa. In this transition zone, optical illusions were described, which consisted in the upward and downward movement of a so-called afterimage. These have been termed "oculo-agravic" illusions, as described by Gerathewohl and Schock.

In addition, the alternation of weightlessness and high accelerations, as may be expected during the ascent and re-entry of a space vehicle, seems to present hazards by decreasing acceleration tolerance and the efficiency of physiological recovery mechanisms.

In 1953, the author included in an early series of experiments certain flights in which the pullout before entering the weightlessness parabola—which normally does not exceed a 2-g value—was made at high speed and so abruptly that values up to 6.5 g resulted. Control runs were made with the same high-g pullout, but without subsequent weightlessness, and instead were followed by unaccelerated horizontal flight. It was found that blackout lasted longer and discomfort and disorientation were stronger when the recovery from the g-stress took place in the weightless state.

After these early observations, no more airborne experiments on alternation of weightlessness and accelerations were reported, until Soviet IGY data were released about Sputnik II's passenger, Laika. This data noted that "the accelerated heart rate of the animal, produced by the acceleration of the thrust, returned gradually to the normal rate after entry into the weightless state. It took, however, about three times as long for the number of heart beats to reach their initial values as it did in laboratory experiments, when the animal was subjected to accelerations similar to the launching accelerations."

**Post-weightlessness acceleration brought blackout and severe substernal pain to these two pilots. The top two frames in each strip show the pilot still in the weightless state; the succeeding frames show the onset of acceleration and pilot blackout.**

The aspects of alternate acceleration and weightlessness have today a special importance because this condition will occur during the ascent and re-entry of a rocket vehicle. In biosatellite experiments, the subject will have to endure an accelerative phase from launching until burnout of the engine. The transition from this powered ascent to weightlessness will be very abrupt, since vehicle designers prefer an abrupt burnout to a gradual one. On the other hand, during orbital and space flights, the subject would remain in the weightless state for hours, days, or weeks, and during re-entry would again be exposed to considerable g-loads.

The author, in his early experiments, termed the pattern flown as "post-acceleration weightlessness." However, under these new circumstances, since the reactions to accelerations with preceding or subsequent weightlessness are to be studied, an inversion of the nomenclature seems more convenient, with *pre-weightlessness accelerations* used for the ascent patterns and *post-weightlessness accelerations* for the re-entry patterns.

### Jet Aircraft Used in Tests

The author recently conducted experiments with jet aircraft simulating these alternating periods of g-loads and weightlessness. By means of tight, continuous turns, subjects were exposed to positive accelerations of up to 6 g for periods of as much as 1 min. These accelerations produced a pronounced "blackout" of the subject in several cases. Accelerative stress was preceded or followed by a 45-sec Keplerian trajectory which produced weightlessness.

The installation of the bulky recording equipment in the narrow cockpit of the F-94C interceptor was rather difficult, as can be seen from the photo on page 27. The weightless state itself did not cause problems in the functioning of our recording equipment. Instead, the high g-loads interfered with normal functioning of recording devices such as the motion picture camera (jamming of magazines), and necessitated keeping up the structural strength of the instrument rack and equipment mounts.

The subject was instructed to sit upright and to avoid straining or "fighting the g's," while the pilot was protected by an anti-g suit, and was allowed to increase g-tolerance by

crouching forward. In this way, it was possible to blackout the subject while leaving the pilot in full possession of his senses and in control of the aircraft. The subject was told to describe his impressions and his symptoms via a microphone hooked up both to a miniaturized tape recorder on his left leg and to the aircraft radio system. During each test, the aircraft was in continuous communication with a ground station. The entire conversation was recorded both on the ground and on the subject's tape recorder. This assured preservation of verbal data even in the event of radio failure.

The two-way radio installation also provided an opportunity to initiate some psychological studies. From the ground station, a research psychologist asked test questions, with word-association, inverted number repetition, syllable completion, and drawing tests used. The responses were compared to others recorded both before and after the flight on the ground. Subjects reported increased susceptibility to or severity of acceleration effects when they entered positive-g states immediately after experiencing weightlessness. Subjects who normally blacked out at 5 g could tolerate only 3.5 to 4 g in the experiments.

In the opposite case, when acceleration preceded weightlessness, physiological recovery mechanisms seemed disturbed. Blackout lasted longer and more severe discomfort and chest pains were reported. Cinematographic observation, registration of heart rate, electrocardiogram, and galvanic skin responses corroborated the subjective reports.

Other problems could arise in space flight of longer duration. Extended weightlessness may very likely lead to lessened muscle tone and strength. Therefore, devices similar to ergometers should be used to exercise the muscles during space travel.

Other inconveniences can be expected for the circulatory system. The heart, used during weightlessness to transport the blood column without the force of gravity, would need a certain time for adaptation after reentering the gravity field of the earth or another planet.

One example can help illustrate this situation: A person who has been ill and confined to bed for several weeks and then stands up for the first time is likely to experience a so-called orthostatic collapse, because here also the cardiovascular system has lost the ability to compensate for the hydrostatic forces of 1 g.

We can conclude that the greatest significance of zero gravity in space flight will not be difficulties originated by weightlessness per se. Rather, the weightless state aggravates other conditions which, in combination, may pose challenging problems to astronauts.

## Dornberger on Dyna-Soar

Walter R. Dornberger, technical assistant to the president of Bell Aircraft Corp., and generally credited with originating the Dyna-Soar concept, recently suggested some possible uses for such a vehicle.

Describing Dyna-Soar as a cross between a guided missile, a rocket and a glider, which would have global range, near-satellite speeds at very high altitudes and the ability to land in a preselected area, Dr. Dornberger saw many uses for the vehicle—as a space laboratory, as a military reconnaissance platform, and as a ferry.

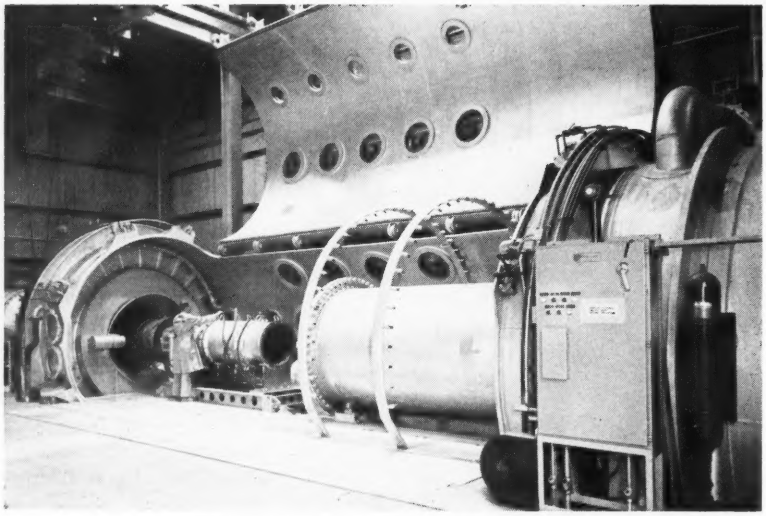
Asked about the timetable for man in space, Dr. Dornberger said he felt a man could be put in an orbital vehicle and returned to earth within a year, but that it would take four or five years to reach the point where a man could be brought safely back from orbit to a predetermined spot.

space
nated
r, the
con-
may
astro-

al as-
l Air-
edited
con-
ssible

ss be-
and a
range,
h alti-
in a
r saw
space
ssance

r man
he felt
orbital
ithin a
our or
here a
back
pot.



## Hypersonic Ramjet Engine Test Stand at Marquardt

**This stand at Marquardt's modernized Jet Lab in Van Nuys, Calif., will test 6 ft diam ramjet engines with up to 5000 lb thrust at simulated altitudes approaching the limit for air-breathing power plants. Stand cell is 14 ft in diam and 80 ft long.**

### Preparing Man for Space Flight

(CONTINUED FROM PAGE 21)

*Medicine*, 26: 268–288, 1955). Hospitalization of several days was not uncommon for men sled-tested. It is now a valid point of view that, given suitable protection, man may tolerate higher levels of acceleration and for periods much longer than had been thought possible.

For the success of man in space, the crew should be as familiar as possible with all the stresses and emergencies which they might meet. Some of these situations may require rapid and precise reactions for survival. There may be, for instance, an overreaction to anything unexpected.

The mental environment of the spaceman, moreover, focuses down on what we, in the presumably calm atmosphere of our offices, consider to be but a small part of the total environment. Recently a test pilot "crashed" the X-15 centrifuge simulator on one of his first few dynamic flights, to later comment "I was concentrating on the g-meter." This was only one of several important instruments for proper control during part of the re-entry, as he knew from hours of static-simulator practice.

It is a primary requirement that the space pilot will be provided local environments which, if properly utilized, isolate him from the greater part of his hazards. By training it will be possible to make situations seem routine which at first are extremely stressful.

There are two approaches to training for space flight. One is the older method, illustrated by the early NACA aircraft-research program of moving higher and faster in small steps, repeated with respect to all aspects that are different by each pilot. The other approach to training is by simulation, a method of increasing importance now that the cost of simulating a flight has become significantly less than the cost of the actual flight, even if the latter involves no accidents.

#### Simulation Must Be Very Good

Although one can say that there is no substitute for reality, one must also admit that there is no substitute for being prepared for this reality. With the simulation technique, crews could maintain proficiency on the ground throughout the experimental envelope of the vehicle. Any crew could be used to extend the envelope, perhaps still in small steps, bringing back information which, added to the simulator, would extend the envelope for all. For this to be possible, the simulation must be very good. Thousands of ground "flights" would be made for each actual flight.

Simulation techniques have developed initially for each of the hazards of space separately. At present, there are available pressure chambers, thermal chambers, noise chambers centrifuges, linear tracks, shake tables, aircraft ballistic trajectories for zero-g studies, "fixed base" cockpit computer simulators for the study of controls, adequacy of controllability, displays, and control techniques, tracking and landing simulators as refinements of the last, etc. The need is to combine these separate devices to provide, with as much reality as possible, the total experience of crew sensory read-in, decision making, and read-out.

#### "When In Doubt Add Parameter"

Certain parameters of the environment seem less significant than others in affecting the crew facilities, and these might receive less emphasis in the simulation. But the point of view in simulation work should be "when in doubt add the parameter" for "desk" evaluation of importance may be quite different from flight evaluation. Biologists, for instance, are just beginning to work on responses of the body to combined stresses; it cannot be predicted whether a man who can perform adequately during two separate stresses will do the same when the stresses are combined. Perhaps the quickest approach is the detailed simulation of the particular local environment of concern. Finally, at every opportunity a simulation should receive flight comparison with subsequent validation or improvement.

To simulate the flight accelerations of a particular aircraft, one can use either a human centrifuge or a variable-stability aircraft. Linear track devices thus far do not have the power and length for long-duration accelerations. Aircraft motion has six degrees of freedom; the detailed reproduction of the time histories of its three linear acceleration components and three angular acceleration components would require the full displacement and speed capabilities of the aircraft itself. For slower vehicles, the variable-stability aircraft can carry out an essentially perfect simulation. For faster vehicles, the variable-stability aircraft has generally been flown (particularly by NASA and Cornell Aeronautical Lab) to simulate the linear accelerations, with some sacrifice of accuracy in simulating angular accelerations. Available power and the strength of the variable-stability aircraft limit the durations and magnitudes of accelerations which can be simulated with them.

Human centrifuges are constrained in motion, yet can have the power and strength to simulate accelerations well beyond those of present vehicles. For experiments fixed on the centrifuge arm or mounted in free-swinging car-

riages, these centrifuges have but one degree of freedom of control; the other five parameters of the vehicle motion are generally incorrectly matched during the simulation.

The AMAL centrifuge, shown on page 18, is an exception. The only human centrifuge with a powered double gimbal system, it has three degrees of freedom of control. Up to the present time, tests with this centrifuge have emphasized simulation of the three linear acceleration components, at a sacrifice of angular acceleration matching.

#### New Technique

For earlier work, the centrifuge was remotely controlled, to give to the subject specified accelerations unaffected by his actions, as if he were a passenger in the vehicle. In July 1957, the new technique of centrifuge dynamic control simulation—with pilot-computer closed-loop control, as illustrated on page 21—was first put into operation, following its development in cooperation with the NADC Aeronautical Computer Lab and Univ. of Pennsylvania consultants.

In this technique, the pilot makes the mission flight control motions, and a computer determines the three linear acceleration components which would have been generated had the pilot made the same control motions in actual flight and drives the centrifuge to deliver these accelerations to the pilot. At the same time, the computer drives the pilot's display instruments, to show the changing conditions of the flight. The pilot then receives all the maneuver loads of flying the vehicle under his own control. Unfortunately, a ground-based centrifuge is unable to provide accelerations of magnitude less than 1 g; for the simulation of outside loops or ballistic flight, the centrifuge is stopped until 1 g is again exceeded.

Three programs of centrifuge simulation of the X-15 research aircraft have been carried out, two using this technique of dynamic control simulation. Some 601 dynamic flights and 991 static flights of the X-15 have been made with the centrifuge simulator during these three programs.

With the centrifuge simulator, it is now possible to examine simulataneously both flight-control performance and acceleration tolerance and determine their interactions. It is proposed for future work to add at least the horizon aspects of the "view out the windows" to provide the peripheral field visual cues important in pilot control orientation. Pressure, temperature, and sound simulation may eventually be added. By providing the pilot with the exact displays, controls, vehicle responses as represented by display changes and linear acceleration components, and with as many of the other sensory cues of the actual flights as possible, the pilot can be trained in the procedures for normal flight and for emergencies. Ideally, it would be desirable to so perfect the flight simulator that a blindfolded pilot could not tell it from the real thing. The expense and hazard of space flight is such that this is the necessary trend in the simulation art.

Space-medicine research cannot wait for the engineers to provide a vehicle to be simulated. This research will probe ahead, determining human limitations of body and performance, and means of obviating these limitations. The high-acceleration work at AMAL and in other laboratories falls in this catagory and is of basic importance to the engineers who will design a vehicle to utilize human capabilities.

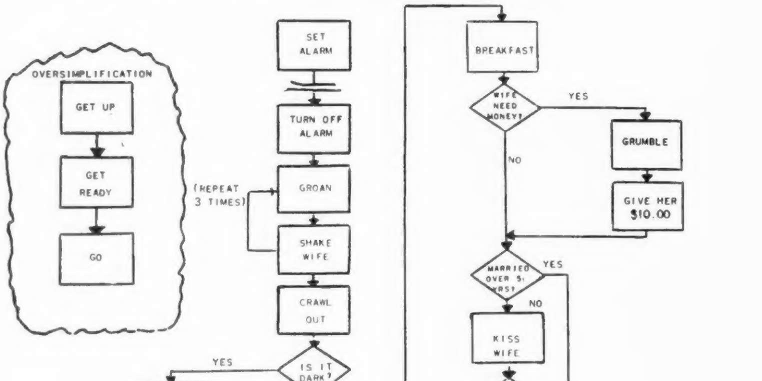
#### Long Duration Acceleration

As an example of the kind of research which can be done, one of the authors recently rode the Johnsville centrifuge at 2 g for 24 hr to study the consequences of long duration acceleration, which had not been determined before. To avoid nausea, he made only slow head motions. He cooked, ate, slept, stood up, made medical observations on himself, wrote and typed, and generally carried out living activities. However, he lost interest in these activities while under stress and passed most of the time listening to the radio and napping.

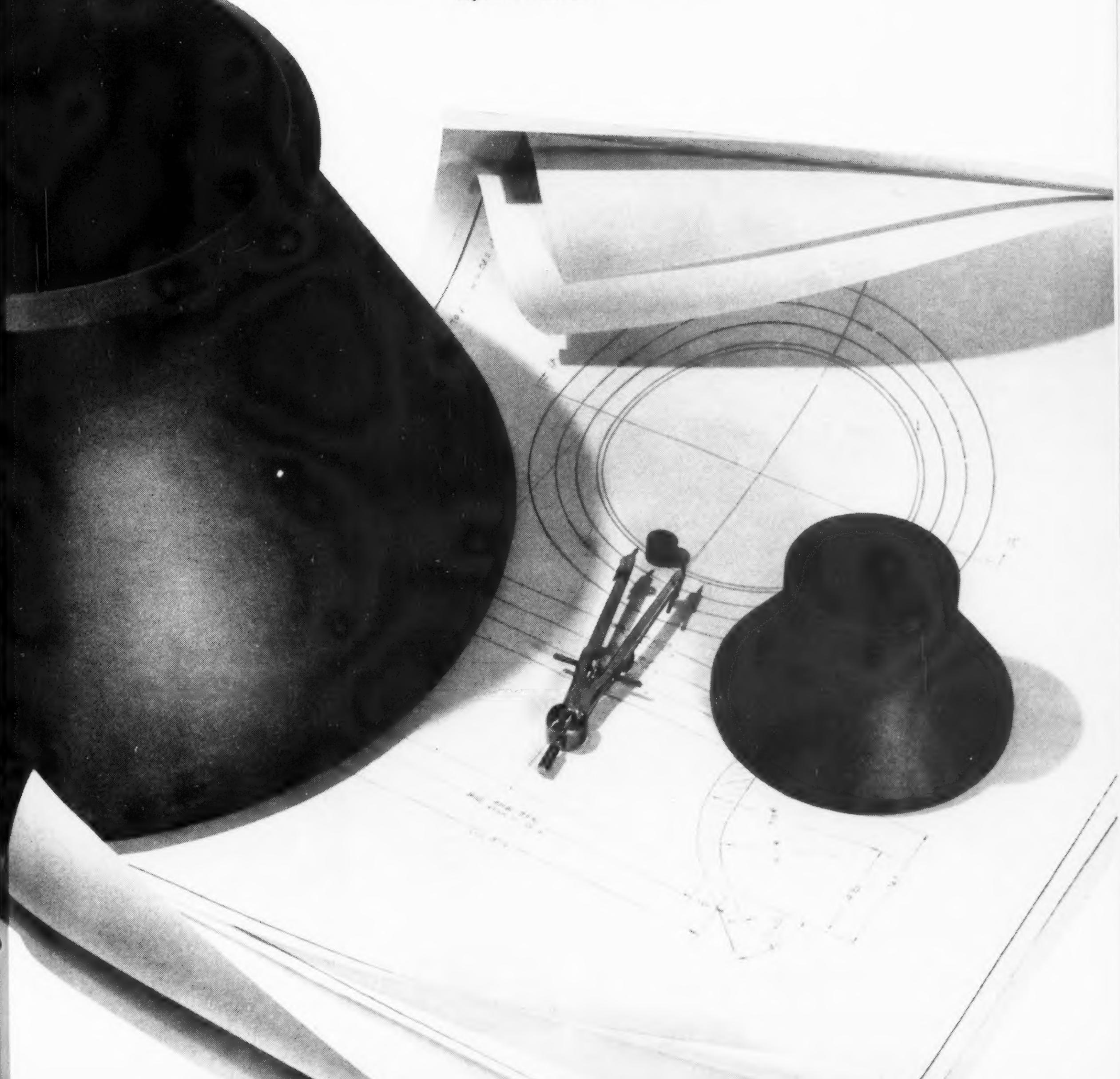
If this 2-g acceleration had been in a straight line, in 24 hr he would have traveled 45 million miles and reached a speed of 3.8 million mph. If he accelerated at 2 g half way and decelerated the other half, he would have reached Mars in 42 hr, made the moon in 3.5 hr, and gone across the country in 15 min.

Through such studies man is evaluating his capacity for space flight, and it is hoped that man will be prepared for space when the engineers are prepared to let him start.

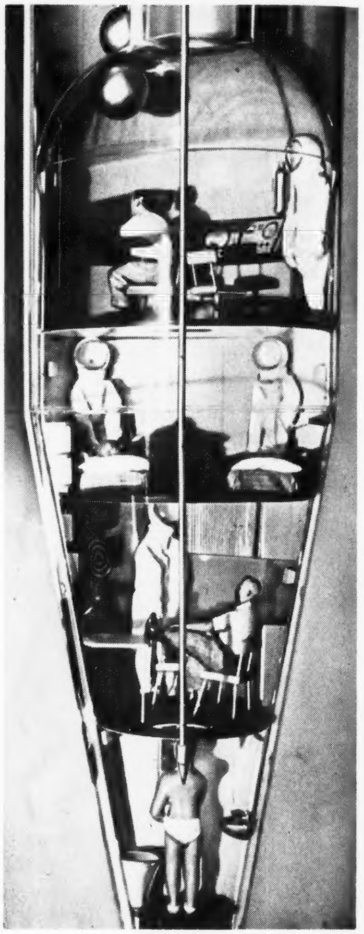
## Program: How to Get Up in the Morning




**Foote Mineral Co., Philadelphia, prepared this diagram to show how programmers have to instruct a computer to work. The step-by-step procedure is patterned after the way in which a function is actually set up on a computer.**

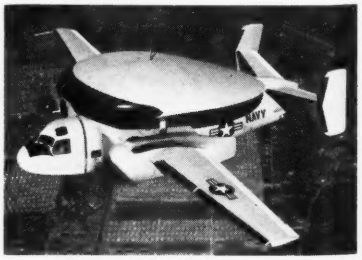


## Proposed Space Station



Model of proposed four-man space station whose crew would live and work in forward tankage of Atlas ICBM 400 miles above earth is released by General Dynamics, producer of the Atlas. Top to bottom: control and instrumentation room; sleeping facilities; eating and recreation room; and wash room.

## Flying Saucer?




First Grumman production model of WF-2 Tracer early warning plane is shown during successful flight. Saucer-shaped top houses long-range detection equipment designed and produced by Hazeltine Electronics.

# From the patent office

By George F. McLaughlin

## Attitude Control for Space Vehicles

Conventional techniques for controlling the attitude of aircraft depend upon the reaction torques from air against the rudder, elevator, and ailerons. However, a vehicle moving beyond the atmosphere of the earth cannot be controlled in this manner because of the absence of fluid to react with the vehicle.

This invention provides a means for displacing a weighted material at a controllable rate and in a desired direction so as to produce variable moments of momentum which can control vehicle attitude independently of the absence or presence of an outside fluid medium. The invention employs at least one endless ring member, which is controllably and reversibly rotated about a desired axis.

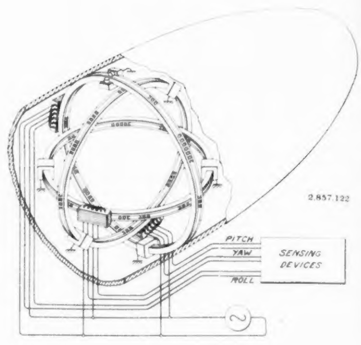
Within the vehicle body are three orthogonally arranged endless rings, one in a plane perpendicular to the roll axis, another in a plane perpendicular to the pitch axis, and the third ring in a plane perpendicular to the yaw axis. Each ring is adapted to be reversedly driven about its axis at variable speeds or maintained motionless by a motor. Each motor is energized by signals from sensing devices such as gyroscopes, accelerometers, or the like, which are shown in the accompanying illustration as being housed in a box labeled "sensing devices."

The electrical-motor means for controlling the rotation and direction of rotation of a ring comprises a two-phase induction motor having a planar stator member with two physically displaced windings, wound within slots and energized by 90 deg time phase displaced a.c. sources, to provide a moving electromagnetic flux. The flux travels a linear path along the stator rather than a rotating path. The ring forms the rotor for this linear motor and is rotated by the motor action occurring between the circulating currents induced in the ring and this traveling magnetic field.

For this reason, the ring is formed similar to a squirrel cage induction rotor. It is provided with an inner band of ferromagnetic material within which is embedded spaced conducting bars aligned transverse to the band. Ends of the band are electrically connected together or shorted by two conducting outer rings fastened on either side of the inner band and connected to the conducting bars.

The traveling magnetic flux induces circulating currents with the rotor, and these currents react after a given phase displacement with this rotating magnetic field to propel the ring along the stator. Speed of rotation of a two phase induction motor may be controlled, within limits, by varying the amplitude of one of the 90 deg phase displaced stator windings, thereby varying the slippage between rotor movement and the speed of the traveling electric field. Similarly, the direction of rotation may be reversed by reversing the phase of one of the stator windings by 180 electrical degrees.

*Patent 2,857,122. Attitude Control System. Michael F. Maguire, Wayne, Pa., assignor to General Electric.*




**Perspective view, partially cut away, illustrates the features of the attitude control for a vehicle operating in outer space.**

## Rocket Stabilized by Rotation of Engine

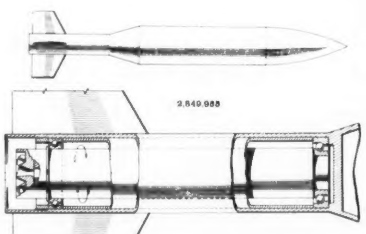
Variations in range and lateral deflection of a rocket caused by malalignments can be minimized by rotation of the rocket in flight. Prior devices took advantage of this principle by rotating the entire projectile.

The adverse effects of malalignments lessen as spin rate of the rocket is increased. However, when increasing the spin of a rocket to overcome the effect of malalignments, a new problem is created—large magnus forces, which are the building up of air pressure on one side of the projectile due to its high rate of spin and slightly unbalanced condition. In attempting to spin the rocket at a low rate, not only do the effects of malalignments become more apparent, but the relatively low spin rate invites resonant instability.

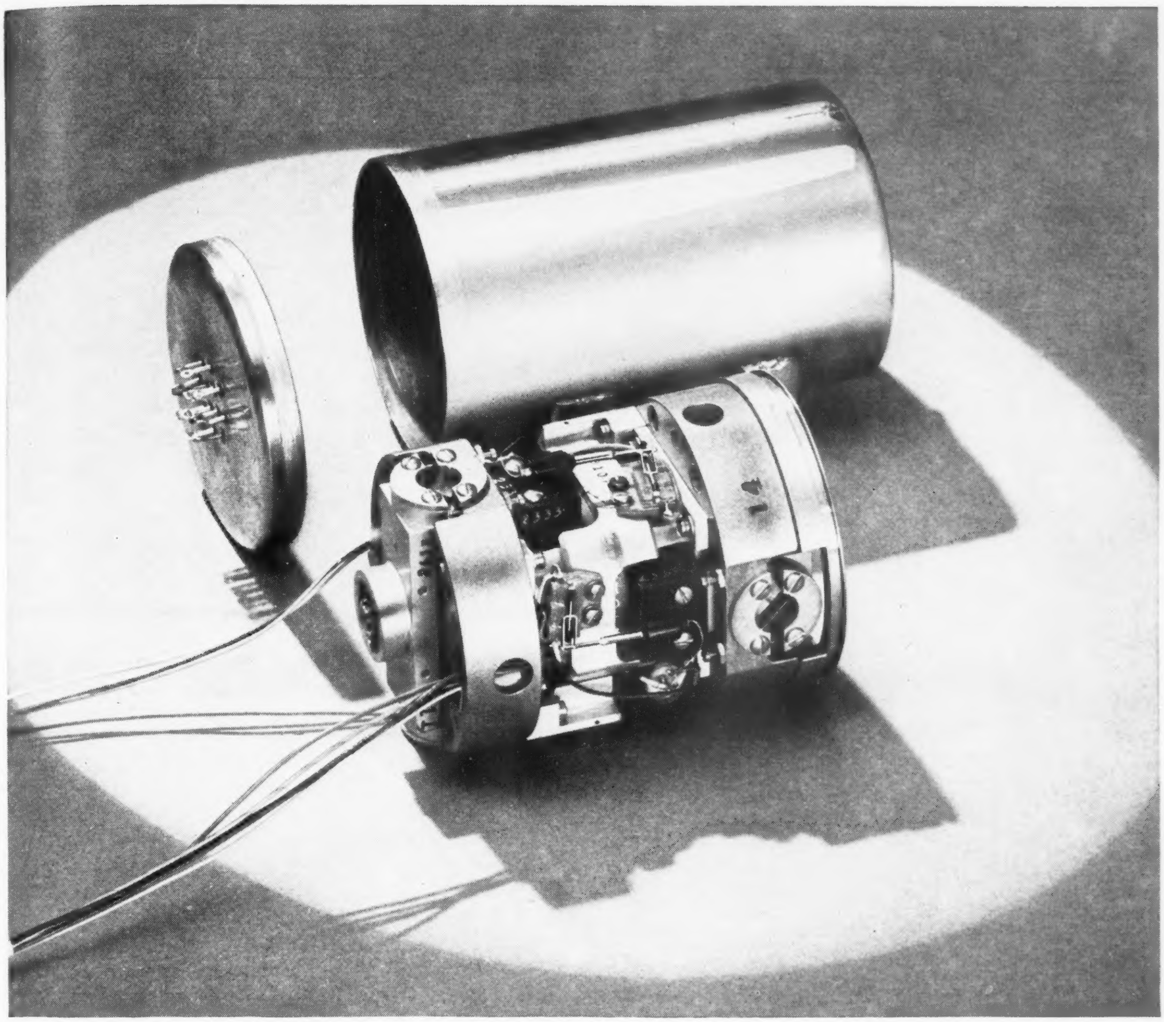
The invention provides a rocket structure which has the advantages offered by the gyroscopic stability produced by high rate of spin but does not introduce magnus forces or resonant instability. The rocket motor with nozzles attached is rotatably mounted within the rocket body, and does not make contact with the outside air. Since the motor and nozzles are not subjected to the outside air, the high spin rate does not create large magnus forces; and, as the motor spins at an extremely high rate, the problem of resonant instability is eliminated. Canted nozzles give the desired spin rate and concomitant internal gyroscopic action for stabilizing the missile.

The invention provides a projectile which has less dispersion round for round by virtue of a consistent variation in moment arm. In addition, this device is suitable for launching from tube or rail launchers, since there are no outer rotating parts.

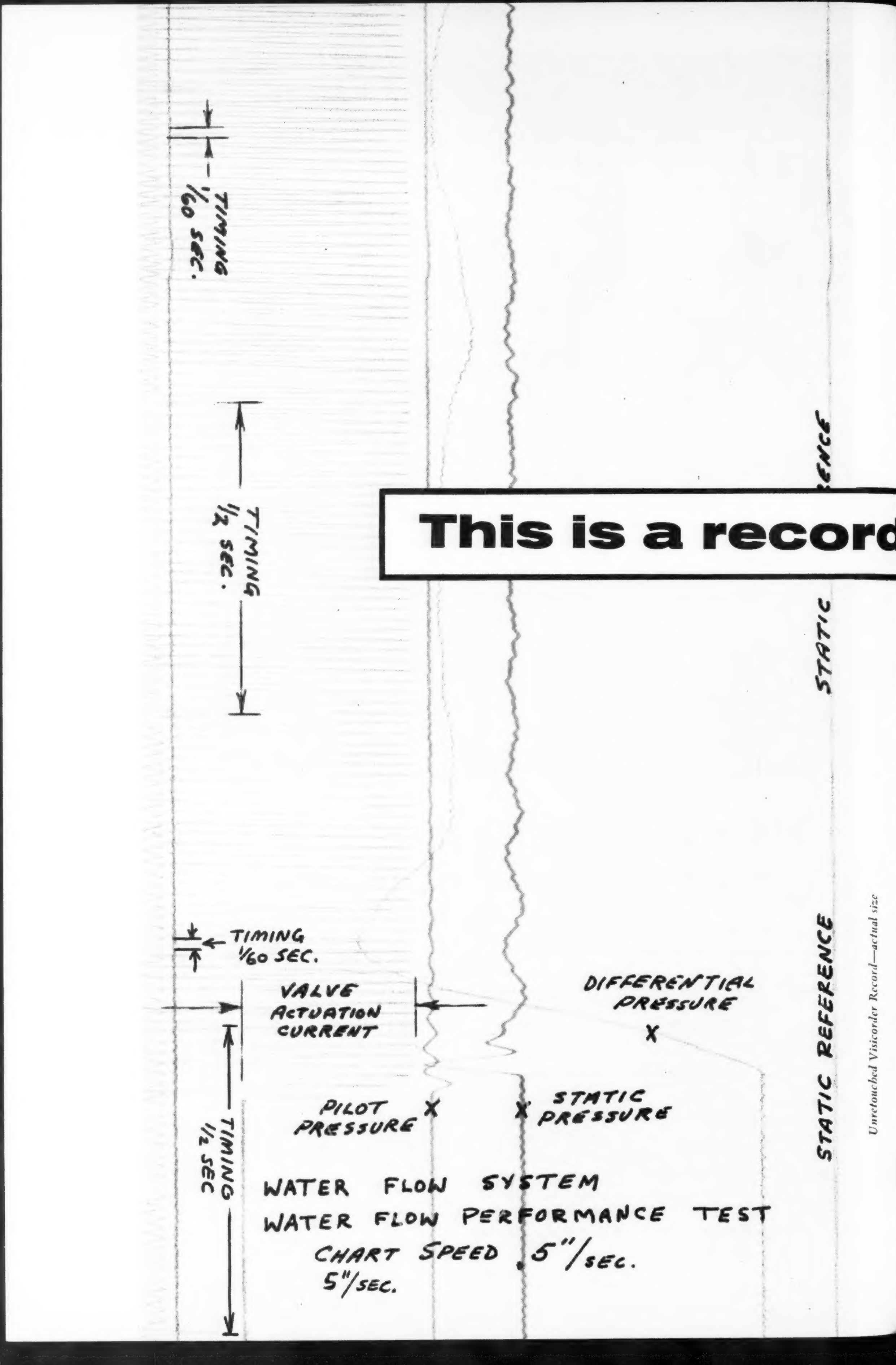
*Patent No. 2,849,955. Rocket Construction. Spurgeon E. Smathers, Hillcrest Heights, Md.*



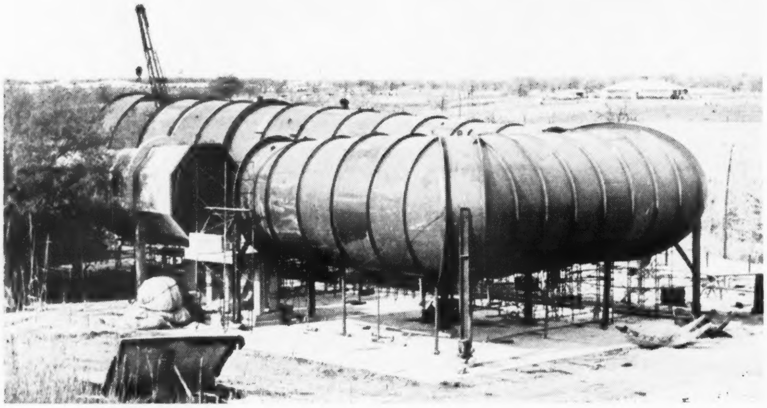

**Plan view and enlarged section of missile, showing power unit rotatably mounted within an extension of the body.**



# This is a record




*Unretouched Visicorder Record—actual size*



## Texas A&M Wind Tunnel

**This 320-ft steel wind tunnel, built for Texas A&M College by Todd Shipyard Corp., will be connected to both ends of the college's existing concrete tunnel for aerodynamic research and engineering, making it a closed circuit.**

## Acceleration

(CONTINUED FROM PAGE 39)

peaks at 12 g, the rate of increase of acceleration was 1 g per 4.5 sec; for the series with three peaks at 10 g, 1 g per 7 sec; and in the series with three peaks at 8 g, 1 g per 12 sec. Tolerance limits were determined subjectively when volunteers lost peripheral vision, were unable to breathe, or felt pain of an intensity that impaired judgment or performance.

Within limits thus defined, a subject would be expected to see, think, and exercise at least finger control, although accuracy of coordination and competency of judgment remain to be evaluated. Experience with the centrifuge and motivation were appreciable factors for subjective limits.

### Immersed Subjects

Tolerance for duration of accelerations of 6, 8, 10, and 12 g in semisupine subjects immersed in a tank of water on the centrifuge has also been studied by Bondurant and Clarke. A skin diver's valve mounted underwater at chest level delivered air for respiration at a pressure equal to the hydrostatic pressure against the chest wall. For the immersed subject, a 35-deg angle of the trunk to the line of force was optimal. Petechiae do not occur even at 12 g and there is freedom of movement regardless of g magnitudes. Free movements of the head increase likelihood of vertigo with increasing acceleration values.

In air, in the conventional seated position, Bondurant and Clarke found that transverse acceleration from front to back caused dyspnea and chest pain, reaching tolerance limits at 8 g. If the trunk is at an angle greater than 70 deg to the direction of acceleration, severe quasipleuritic, anterior chest pain limits tolerance to about 7 g. Decreasing the angle below 70 deg increases a positive g component, resulting in blackout at progressively lower accelerations.

The best tolerances have been obtained with the subject leaning in the direction of acceleration at an angle of 65–70 deg. Elevating the knees until the thighs are parallel with the acceleration force allows a greater displacement of blood toward the trunk, with an effect similar to an anti-g suit. Tolerance was higher than in the previously reported experiments of Ballinger with legs and trunk elevated only 20 deg. In both these positions, respiration becomes difficult above 4 g, and at 6–8 g tolerance time is limited by the ability of the subject to accomplish forced abdominal breathing. Petechiae of the back and anticubital fossae were consistent above 6 g.

All subjects could describe pertinent subjective reactions immediately after the run. Most were able to make coordinated hand and arm movements before the centrifuge stopped. All were able to walk with unsteady gait within 1 min after acceleration. The unsteady gait, along with dizziness, vertigo and, occasionally, nausea persisted for 1 to 5 min after the run.

Transverse acceleration applied from back to front was limited by distribution of the pressure on the body against the restraining harness straps and by the hydrostatic pressure and vascular distention in the legs, congested by acceleration toward the feet. Tolerance limit was 5 g with the legs extended, due to intense calf and thigh pains. Upright seating with the legs at a 90-deg angle to the line of acceleration was optimal, with leg pain and dyspnea limiting endurance above 8 g.

In the positive g position, with the back of the seat tilted backward 13 deg and the legs partially extended, fatigue, backache, and headache limited tolerance to exposures lasting more than 10 min to less than 4 g. At 4 to 5 g blackout was frequent. Occasionally, episodes of profuse sweating, pallor, nausea, tachycardia, and a sensation of imminent syncope occurred without relation to magnitude or duration of positive acceleration. Weakness, dizziness, malaise, and nausea often persisted several hours after these episodes.

In the negative-g position, tolerance was lowest and was limited by head and eye pain.

Except for immersed subjects, arm and leg movements are not likely to be effective in any position above 6 g. Wrists and fingers could be moved in all positions at all g magnitudes.

The equilibrium between gravitational attraction toward the center of the earth and the tangential velocity of a satellite on entry into orbit produces the elliptical path it follows around the earth, and results in a zero gravity condition at the satellite. The weightlessness which this causes in the case of living occupants of a satellite has defied ground simulation.

### Exposure Effects

The brief exposures obtained with aircraft in zero-gravity trajectories for less than 30 sec have undetermined application in evaluating long-duration physiological effects for hours and days of exposure in orbit. The 1952 report of Henry, et al., on rocket ascents of mice and monkeys to 60 km (37 miles), with recovery of subjects, indicated no persistent or irreversible effects of exposure to zero g for less than 3 min.

The only experiment on orbital zero gravity physiology to date was incompletely reported in a verbal communication by Russian neurophysiologist Kutzinov at the 3rd European Aeromedical Congress, Lauvain, Belgium, last September. As scientist in charge of the dog experiment carried by the second Russian Sputnik, he re-


solving
critical
control
problems
for
space-age
progress
WHITTAKER GYRO
BRUBAKER ELECTRONICS
DATA INSTRUMENTS
ENGINEERING SERVICES
WHITTAKER CONTROLS
NUCLEAR INSTRUMENTS
TELECOMPUTING CORPORATION
915 NORTH CITRUS AVENUE
LOS ANGELES 38, CALIFORNIA

ported that telemetered records of circulatory status showed the base-line status required three times as long to be re-established as it did in ambient 1 g following centrifuge simulation of the rocket accelerations on the same animal at ground level. He qualified this by stating that effects of noise, shock, and vibration involved in ascent of the rocket had not been ruled out by simulated exposure in the centrifuge control experiment. Conceivably, comparable disturbance and delay of reflex adjustments to restoring accelerative environment during re-entry deceleration is a possibility.

The threshold for this adjustment is decreased by brief exposure to zero gravity, and von Beckh has observed that the tolerance to re-entry accelerations following prolonged weightlessness in orbit may be appreciably lowered. Very gradual onset to 3 g or less for re-entry may be all that can be tolerated.

### Prolonged Accelerations

Prolonged accelerations corresponding to re-entry decelerations from space flight were best tolerated in the seated position with the trunk at a 65-deg angle to the thighs, which were in line with the front-to-back, transverse acceleration. Tolerance was 2 g higher than in the semirecumbent 20-deg trunk and leg elevation position. Continuous acceleration above 8 g is limited by blackout or dyspnea. With the rate of onset slow enough to allow reflex cardiovascular compensatory mechanisms to adjust before maximum acceleration was reached, 3 g could be maintained for 1 hr.

Immersed subjects could endure acceleration for twice the duration reported for nonimmersed subjects up to 12 g. Tolerances above 12 g have not been investigated.

Stoll and Mosely found that chimpanzees in the fully supine position could endure centrifuge accelerations up to 40 g for 60 sec, although vascular damage was encountered at 40 g in the semisupine and semiprone positions.

In summary, accelerations of less than 4 g are tolerable in either chest-to-back, back-to-chest, or foot-to-head direction for durations sufficient to exceed escape velocity. Tolerance time is increased more than twofold by water immersion. Three-stage accelerations with peaks up to 12 g, sufficient to reach orbital velocity, can be withstood in the transverse, front-to-back direction with the subject seated and the trunk forming an angle of 65 deg to the extended legs.

Abrupt linear forces such as might be encountered in opening shocks of recovery parachutes following re-entry or during impact of landing on hard surfaces have been investigated by the author to the limits of voluntary human tolerance, and with anesthetized chimpanzee subjects, to injury and lethal limits. A rocket-powered sled mounted on rails holding the subject and instrumentation was accelerated to sonic velocities in 5 sec and decelerated by water inertia to a stop in less than 0.4 sec in distances as short as 50 meters (164 ft) from velocities of 300 meters/sec (984 ft) in determining injurious and lethal limits for chimpanzees seated facing forward. Injuries and death were the result of pulmonary and cardiovascular trauma.

Survival limit for transverse decelerative force applied from front to back in lightly anesthetized chimpanzees optimally restrained by nylon webbing was reached at a 237-g peak with 11,250 g per sec rate of onset and 0.35 sec total exposure duration. Persistent injury was found above 5000 g per sec rate of onset, 135 g peak and 0.35 sec duration, although transient injury effects were observed at 60 g at higher than 5000 g per sec rate of onset in the transverse direction.

Decelerations of less than 40 g at rate of onset lower than 600 g per sec and total duration below 0.2 sec, comparable to decelerating from 194 km per hr (120 mph) in 5.8 meters (19 ft) can be survived with no persistent injury by subjects restrained adequately while seated facing either forward or backward to the direction of linear force.

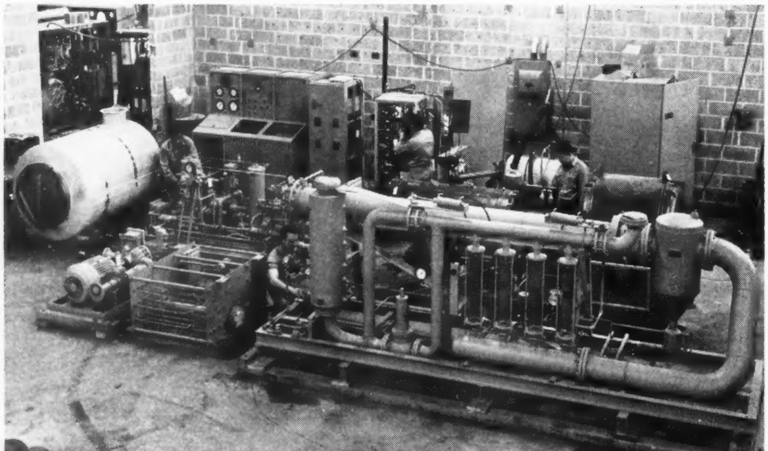
### Man-in-Space Requirements

Should present three-stage ballistic rocket systems be used for putting man in space, the required accelerations of the stages can be tolerated for the necessary durations if they do not exceed 10 g and if the subject can be optimally positioned for the ordeal. The transverse position facing the direction of accelerations with trunk bent forward at a 65-deg angle with respect to the thighs proves best for sustaining such a stress. Immersion in water increases the duration of endurance and mobility of the extremities, but is redundant for present configurations of acceleration that will reach orbiting velocities.

A more promising prospect from the standpoint of human effectiveness is found in extremely prolonged accelerations of less than 4 g. Tolerance that is not exceeded by more than 1 hr of exposure to 3 g attained by gradual onset in both the transverse and positive g orientations offers the possibility of exceeding escape velocity by tenfold. With means of propulsion for space vehicles that will provide continuous accelerations not exceeding 4 g, for durations to attain orbiting or escape velocity, the experience is within the range of physiological adjustment, and does not impose on the capacity for recovery.

Based on a paper presented at the ARS 13th Annual Meeting in New York City, Nov. 17-21, 1958.

## Bomarc Engine Test Stand



**This test stand will be used at Patrick AFB to check out Bomarc ramjet engines. Stand was built by Greer Hydraulics, Inc.**

## Sun Follower

**A heliostat built into this solar furnace by GE missile engineers keeps the furnace's face constantly turning toward the sun. On cloudy days, a high-powered searchlight is substituted, as shown, and temperatures as high as 5000 F have been recorded. Sun heat has achieved 6000 F.**

---

### Closed-Cycle System

(CONTINUED FROM PAGE 37)

by the breathing requirements as no less than 5 psia.

The system we have worked on differs from earlier closed breathing systems, such as those used in balloon gondolas and underwater breathing devices, in that the two major functions, ventilation and respiration, are served by the same confined gas stream. The recirculation rate of 10 cfm, set by the cooling requirement, is several times greater than the rate needed for respiratory supply or for processing equipment.

This system was designed for experimental purposes to fulfill the physiological and environmental requirements of a 12-hr mission simulated in an environmental test chamber.

A description of a few of the components is in order because of the unique application of well-known principles. For example, it was deduced that, for these particular conditions, packaging oxygen as a gas at 7500 psig results in minimum weight and volume compared with low-pressure gas containers or liquid converters. The high pressure necessitated development of a combination single-stage pressure regulator, filling valve and shut-off valve that would deliver oxygen to the system-pressure controller.

In addition, a novel system-pressure controller with no leakage was developed. This controller maintains a few inches of water positive pressure above ambient pressure to an altitude of 27,000 ft, and then automatically maintains pressure at 5 psia above this altitude. It is able to do so even during simulated supersonic ascents and descents. A condensation-evaporation scheme charges the supply to 7500 psig.

$CO_2$-removal equipment makes maximum use of an absorbent. A bypass proportions the flow so that no more than the equivalent of 1 per cent $CO_2$ at 14.7 psia returns to the man for breathing. The bypass also reduces pressure loss through the packaged absorbent.

The system also features a small positive-displacement circulating blower, capable of delivering 10 scfm against 20 in. of $H_2O$ pressure head with a power consumption of but 120 watts, and a temperature conditioner and water-removal unit which uses conversion of ice to water to steam as a heat sink. Control is effected by automatically fixing the number of active passes in a four-pass heat exchanger.

One important goal was to package system parts into a box of minimum size and weight. In experimental form, the system measures 7 x 22 x 28 in. and weighs 80 lb fully charged. This weight could be reduced sharply by selecting lighter construction materials and by optimizing the heat exchanger for the smaller loads now predicted for actual flight.

Another goal was to make the system independent of the vehicle. This was achieved in all respects save one —the electric power needed to drive the pump. Even this shortcoming can be overcome by any of several methods.

Tests have been made with the system using a special full-pressure suit designed for low leakage and a temperature-controlled altitude chamber. The photograph on page 37 shows a subject in the chamber being supplied through the experimental equipment. The object of the tests has been to check both system performance and the adequacy of the stored oxygen, carbon dioxide absorber, and heat sink.

To monitor the system, a set of gas analyzers was used to provide a continuous record of the partial pressures of oxygen, nitrogen, carbon dioxide, and water vapor. These four gases should make up virtually all the contained atmosphere, and the four partial pressures should equal total pressure in the system. This worked out nicely, as shown by the plot of test results on page 37. The curves are taken from data from a run with chamber temperature at 80 F and chamber pressure 2.1 psi (110 mm Hg, or 45,000 ft equivalent altitude).

Suit and system total pressure was maintained near 5 psia, as shown in the graph. It was interesting to see how much residual nitrogen remained in the system. A study is being made to determine whether this is a physiological finding or some sort of experimental peculiarity related to the chamber test setup. The 40 mm Hg of nitrogen persists despite repeated washouts with pure oxygen.

Other instrumentation was used for determining pressure drops across components of the system, temperature levels at different points, and the physiological additions of $CO_2$ and water by the man to the gas stream. The entire test setup is not only a potentially useful device for future vehicles, but also a rather complete experimental tool for confirming important physiological variables in man.

The design time of 12 hr has been met handily by the stored components. Oxygen, lithium hydroxide, and water stored in the system have proved in excess of actual requirements for a 12-hr run, thus verifying safety factors built into the design. Actual oxygen consumption and $CO_2$ production have been only just above the basal level for a resting man. These show an oxygen use rate of about 400 cc/min, of which 130 cc/min is leakage from the suit.

#### B/V Systems Prove Superior

Temperature controls and cooling have been satisfactory to date, although maximum heat loads have yet to be run in the chamber. It appears from other tests, however, that the heat exchangers are more than adequate to meet design cooling rates.

The feasibility of closed-cycle breathing/ventilation systems and their superiority over open-cycle systems has been demonstrated. Much work remains to be done in optimizing processes and equipment, both individually and in system assembly, for minimum weight and volume with high reliability. Each vehicle will require such an analysis, especially in terms of planned mission duration.

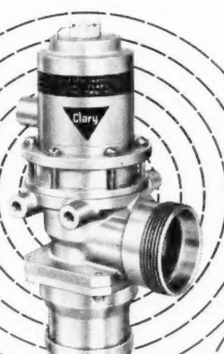
This type of closed, nonregenerating system appears to be the best solution for relatively short missions, lasting from 12 to 48 hr. Flights of much longer duration will call for equipment in which weight does not increase with time.

# Clary brings you valves...

*for extreme accuracy under wide variations in inlet pressures and flow*

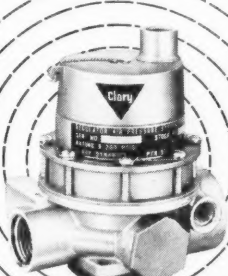
These Clary high-flow pressure regulator valves maintain outlet pressures with extreme accuracy under wide variations in inlet pressures and flow. Each incorporates a pneumatic amplifier to control large forces with a small signal energy, and is designed for use in a wide variety of jobs.

These valves are engineered and manufactured by Clary – the company whose long experience, outstanding staff, and complete facilities for extreme environmental testing have made it one of the nation's largest manufacturers of rocket and missile valves.



**ABSOLUTE PRESSURE REGULATOR** maintains an outlet pressure of 18½ to 20 PSIA with variations in flow rate from 3 to 350 SCFM under 30 to 100 PSIA inlet pressure and −65°F. to +350°F.

**Weight:** 2.1 pounds **Length:** 8.55 inches
**Tube Size:** Inlet: 1.50 inches
Outlet: 2.00 inches



**DIFFERENTIAL PRESSURE REGULATOR** maintains an outlet pressure of 6 PSIG ±.25 with flow variations from 3 to 160 SCFM under 10 to 250 PSIG inlet pressure and −65°F. to +350°F.

**Weight:** 1.5 pounds **Length:** 4.00 inches
**Tube Size:** Inlet: .75 inches
Outlet: special flange

Clary

***Clary Dynamics***
*San Gabriel, California*
*Manufacturer of business machines, electronic data-handling equipment, aircraft and missile components.*

## Sun Follower

**A heliostat built into this solar furnace by GE missile engineers keeps the furnace's face constantly turning toward the sun. On cloudy days, a high-powered searchlight is substituted, as shown, and temperatures as high as 5000 F have been recorded. Sun heat has achieved 6000 F.**

---

## Closed-Cycle System

(CONTINUED FROM PAGE 37)

by the breathing requirements as no less than 5 psia.

The system we have worked on differs from earlier closed breathing systems, such as those used in balloon gondolas and underwater breathing devices, in that the two major functions, ventilation and respiration, are served by the same confined gas stream. The recirculation rate of 10 cfm, set by the cooling requirement, is several times greater than the rate needed for respiratory supply or for processing equipment.

This system was designed for experimental purposes to fulfill the physiological and environmental requirements of a 12-hr mission simulated in an environmental test chamber.

A description of a few of the components is in order because of the unique application of well-known principles. For example, it was deduced that, for these particular conditions, packaging oxygen as a gas at 7500 psig results in minimum weight and volume compared with low-pressure gas containers or liquid converters. The high pressure necessitated development of a combination single-stage pressure regulator, filling valve and shut-off valve that would deliver oxygen to the system-pressure controller.

In addition, a novel system-pressure controller with no leakage was developed. This controller maintains a few inches of water positive pressure above ambient pressure to an altitude of 27,000 ft, and then automatically maintains pressure at 5 psia above this altitude. It is able to do so even during simulated supersonic ascents and descents. A condensation-evaporation scheme charges the supply to 7500 psig.

$CO_2$-removal equipment makes maximum use of an absorbent. A bypass proportions the flow so that no more than the equivalent of 1 per cent $CO_2$ at 14.7 psia returns to the man for breathing. The bypass also reduces pressure loss through the packaged absorbent.

The system also features a small positive-displacement circulating blower, capable of delivering 10 scfm against 20 in. of $H_2O$ pressure head with a power consumption of but 120 watts, and a temperature conditioner and water-removal unit which uses conversion of ice to water to steam as a heat sink. Control is effected by automatically fixing the number of active passes in a four-pass heat exchanger.

One important goal was to package system parts into a box of minimum size and weight. In experimental form, the system measures 7 x 22 x 28 in. and weighs 80 lb fully charged. This weight could be reduced sharply by selecting lighter construction materials and by optimizing the heat exchanger for the smaller loads now predicted for actual flight.

Another goal was to make the system independent of the vehicle. This was achieved in all respects save one —the electric power needed to drive the pump. Even this shortcoming can be overcome by any of several methods.

Tests have been made with the system using a special full-pressure suit designed for low leakage and a temperature-controlled altitude chamber. The photograph on page 37 shows a subject in the chamber being supplied through the experimental equipment. The object of the tests has been to check both system performance and the adequacy of the stored oxygen, carbon dioxide absorber, and heat sink.

To monitor the system, a set of gas analyzers was used to provide a continuous record of the partial pressures of oxygen, nitrogen, carbon dioxide, and water vapor. These four gases should make up virtually all the contained atmosphere, and the four partial pressures should equal total pressure in the system. This worked out nicely, as shown by the plot of test results on page 37. The curves are taken from data from a run with chamber temperature at 80 F and chamber pressure 2.1 psi (110 mm Hg, or 45,000 ft equivalent altitude).

Suit and system total pressure was maintained near 5 psia, as shown in the graph. It was interesting to see how much residual nitrogen remained in the system. A study is being made to determine whether this is a physiological finding or some sort of experimental peculiarity related to the chamber test setup. The 40 mm Hg of nitrogen persists despite repeated washouts with pure oxygen.

Other instrumentation was used for determining pressure drops across components of the system, temperature levels at different points, and the physiological additions of $CO_2$ and water by the man to the gas stream. The entire test setup is not only a potentially useful device for future vehicles, but also a rather complete experimental tool for confirming important physiological variables in man.

The design time of 12 hr has been met handily by the stored components. Oxygen, lithium hydroxide, and water stored in the system have proved in excess of actual requirements for a 12-hr run, thus verifying safety factors built into the design. Actual oxygen consumption and $CO_2$ production have been only just above the basal level for a resting man. These show an oxygen use rate of about 400 cc/min, of which 130 cc/min is leakage from the suit.

### B/V Systems Prove Superior

Temperature controls and cooling have been satisfactory to date, although maximum heat loads have yet to be run in the chamber. It appears from other tests, however, that the heat exchangers are more than adequate to meet design cooling rates.

The feasibility of closed-cycle breathing/ventilation systems and their superiority over open-cycle systems has been demonstrated. Much work remains to be done in optimizing processes and equipment, both individually and in system assembly, for minimum weight and volume with high reliability. Each vehicle will require such an analysis, especially in terms of planned mission duration.

This type of closed, nonregenerating system appears to be the best solution for relatively short missions, lasting from 12 to 48 hr. Flights of much longer duration will call for equipment in which weight does not increase with time.

## Space Cabin Atmosphere

(CONTINUED FROM PAGE 29)

pressure of 418 mm Hg, corresponding to 55 per cent oxygen at sea level atmosphere. Although the men performed well throughout the experiment, evidence of beginning oxygen toxicity was obtained. In two subjects, a decline in vital capacity was found. Substernal "distress" was reported by all subjects from the second day on, as described by E. L. Michel and R. W. Langevin. X-ray studies at the end of the experiment revealed in one case existence of an atelectatic area.

Results of these studies are extremely valuable for considerations of a sealed-cabin atmosphere, since they show the tolerance limits to oxygen for a period of seven days at 10,000 ft and indicate the necessity for having a sufficient concentration of nitrogen or other inert gases in the atmosphere to prevent atelectasis in parts of the lungs.

Further evidence concerning the importance of nitrogen was presented by C. M. Hesser at the recent Symposium of Submarine and Space Medicine in New London. He measured the breathholding time of subjects breathing pure oxygen and oxygen-nitrogen mixtures under increased pressure. With equal alveolar oxygen tensions at the breathholding breakpoint, he found a significant increase in breathholding time when nitrogen was present in the atmosphere. Our scanty knowledge about the role of atmospheric nitrogen for gas exchange and other functions of the organism is the cause of indecision in this field. However, the notion appears to be increasing among physiologists that an adequate nitrogen concentration should be maintained in the atmosphere of a sealed space cabin under conditions of prolonged exposure.

These considerations give additional support to the conclusion of Simons and Archibald, namely, that an atmosphere containing 50 per cent nitrogen and 50 per cent oxygen at a total pressure of 349 mm Hg (altitude equivalent of 20,000 ft) represents probably the best solution for the sealed-cabin atmosphere of unshielded satellites. It is perhaps advantageous to propose a range from 40 per cent oxygen at 16,000 ft (165 mm Hg) to 50 per cent oxygen at 20,000 ft (175 mm Hg). This would maintain the oxygen partial pressure in the cabin near sea level values. Under these conditions, the pressure differential between cabin and vacuum outside would amount to 8 and 6.75 psi, respectively.

If, on the other hand, we accept the assumption that it is desirable to maintain the nitrogen concentration at a near normal level, preacclimatization to altitude of space crews has a definite merit. The proposed cabin pressures of 16,000 to 20,000 ft are within the range to which man can acclimatize while breathing natural air.

In a closed space such as a submarine, a number of atmospheric impurities and trace substances have been found, the source of which are generally located in the multitude of technical installations. To name a few: Hydrocarbons, nitrites, sulfites, hydrogens, arsine, carbon monoxide, ozone, etc.

We have also found a 10- to 20-fold increase in condensation droplets and in the number of positive and negative ions in the air of conventional fleet-type submarines during submergence. Condensation droplets are, according to F. Verzar, et al., to a considerable extent retained in the respiratory tract. They might play a role in concentrating toxic trace substances which are present in the atmosphere in subthreshold doses and thereby cause them to reach threshold values. It has been claimed that increased positive ionization of the atmosphere affects the well-being of subjects in an adverse manner. This view has found support in recent findings of A. P. Krueger, et al., who demonstrated a significant reduction of the movements of ciliae of the trachea during inhalation of positively charged air.

### Aviation Toxicology Survey

A survey in aviation toxicology by O. B. Schreuder showed that radio and electronic equipment rate highest as the sources of toxic substances encountered in flight, and account for 56 per cent of all incidents. This suggests that the electronic equipment used in sealed cabins should be thoroughly tested in dry runs for possible production of trace substances of a toxic nature.

Control of other trace substances can be accomplished by locating and removing the sources. For example, hydrocarbons are quite often released from certain paints, and these must be replaced. Electrostatic precipitators can be used to remove dust particles and ions from the atmosphere. However, to what extent does the problem of ionization and condensa-

tion droplets exist in a sealed space cabin? Ionization of the air can be produced by ultraviolet light, according to R. F. Smith. The windows of the cabin will probably screen out most of the ultraviolet. Condensation droplets can, however, according to Verzar, be produced by the visible light which passes through the window glass.

The author has noted that $H_2S$ in the air is transformed in condensation droplets in that way. Everyone who has had experience with experiments in confined spaces knows that the odor presents not a small problem. Odorous gases like $H_2S$ and $NH_3$ given off by humans pass through conventional filters. Attention should therefore be given to developing means for an effective odor control. In general, it might be said that existing threshold limit values for toxic substances should be thoroughly reviewed from the standpoint of appropriateness for continuous exposure in a sealed cabin.

Considerable evidence has been accumulated which indicates that the 24-hr environmental cycles of light and darkness, temperature humidity, and barometric pressure act as time-givers for the organism. A synchronization of the endogenous nearly 24-hr cycles of physiological functions with environmental cycles normally takes place. Animal studies by B. Tribukait have shown that endogenous physiolgical cycles adapt to artificial days lengthened to 28 hr and shortened to 21 hr, but become independent and dissociate from environmental cycles if the artificial day becomes less than 21 hr. To what extent man's endogenous cycles can adjust to changing time scales is not known. This could, of course, be affected by the time consciousness of the individual. Experience in submarines with 12- to 18-hr periodicity of environmental time-givers dependent on submergence times indicates the desirability of simulating 24-hr cycles with light, darkness, temperature, and humidity to maintain optimal or normal efficiency.

Difficulties in obtaining an adequate equilibrium between the respiratory metabolism of man and the systems supplying oxygen and removing carbon dioxide have been discussed by Clamann in relation to a potassium superoxide ($KO_2$) system and a phytosynthetic gas exchanger. However, considerable progress has been made in technical development of a closed-cycle air purification system utilizing algae by the chemical engineering section, headed by A. Bialecki, of General Dynamics Corp. in Groton, Conn., in cooperation with Dean Burk and G. Hobby of the National Institute of Health. D. G. Burk, et al., recently reported some major improvements, consisting of (1) use of a new strain of algae with a higher speed of action, (2) development of a sufficiently compact, very powerful light source, and (3) a more efficient photosynthesis system in which thick cultures and rapid agitation are employed. They demonstrated a unit which can supply three men and requires 1 kg of algae in 3 to 10 liters, depending on the dead space. The unit occupies a space of less than 1 cu ft. Problems related to the adjustment of the respiratory exchange ratio of algae to that of man can probably be solved by varying the nitrogen source of the algae, according to J. Myers.

Further progress in the use of potassium superoxide in atmospheric control has been reported very recently by R. M. Bovard, et al. They enclosed two men in a 210-cu ft chamber for 6–7 hr and were able to control the atmosphere with two cannisters of potassium superoxide, each containing approximately 860 gm. These results are encouraging and raise hopes that we will in the near future have adequate atmospheric control systems for sealed cabins at our disposal.

While space does not permit discussion of all essential parameters of environmental control in the sealed cabin, it is hoped that this paper may contribute to clarification of certain requirements. The complexity of an environmental control loop makes a mathematical treatment desirable. Such an approach has to be based on a thorough review of the physiological and psychological responses within expected environmental ranges leading to an establishment of the degrees of biological freedom necessary to maintain normal performance.

It should be emphasized that man represents an "open system" which has to be fitted into the "closed system" of the sealed cabin. The latter, therefore, must of necessity be designd to incorporate certain features of an open system.

The complete references in this discussion may be obtained by writing to the Editor.

## Wind Tunnel Hits Mach 20

A wind tunnel designed by Raymond L. Chuan for the Univ. of Southern California simulates Mach 20 at an altitude of 60 miles by injecting nitrogen gas into a chamber evacuated by freezing out gas with a helium refrigerator. A small radio transmitter beams its output at the injected gas, heating it before it strikes the test model to simulate aerodynamic heating effects.

# Government contract awards

### Atlas Guidance Equipment

Additional contracts of $17,176,099 and $5,272,469 for Atlas ground guidance equipment have been awarded to Burroughs Corp. by the Air Force Ballistic Missile Div., ARDC.

### Sidewinder R&D Contract

Navy Bureau of Ordnance has awarded Philco Corp. a $1 million contract for continued R&D aimed at improvements for Sidewinder.

### Sidewinder Guidance Pact

Navy BuOrd also awarded Motorola Military Electronics Div. a $1,086,000 contract for development of an improved guidance unit for Sidewinder.

### High-Density Microwave System

Collins Radio Co. has received a $2-million Navy contract for a high density microwave system to be used at the National Pacific Missile Range. When installed, the system will connect the main control center at Pt. Mugu, Calif., and subsidiary centers at San Nicholas Island and Pt. Arguello, for a total transmission of more than 150 miles.

#### Solar Energy Converters

Hoffman Electronics Semiconductor Div. has received two production contracts for Type 120-C high-efficiency converters, or solar cells. The first contract, for $500,000, came from the Signal Corps, Ft. Monmouth, N.J., and the other, for $291,000, from Space Technology Labs.

#### B-70 Shock Wave Control

Hamilton Standard, a Div. of United Aircraft Corp., has been selected from among 10 competing companies to design, develop, and manufacture an air-induction control system to control the position of shock waves formed at supersonic speeds in the engine inlets of the North American B-70 Valkyrie bomber.

#### AFCRC Data-Processing Contract

Stavid Engineering, Inc., has been awarded a contract by the Air Force Cambridge Research Center for installation, test, development, and modification of experimental data processing equipment.

#### Wind Tunnel Instrumentation

Datex Corp. has received a $120,000 contract for two data processing systems to be used for wind tunnel instrumentation at a Columbus, Ohio, naval aircraft plant.

#### $1 Million Computer Award

Kearfott Co., Inc., has been awarded a $1,217,678 Air Force contract for the AJA-1 computer group associated with the B-52 weapons guidance system.

#### Corporal Equipment

Clary Dynamics received some $700,000 in new orders from the Guided Missile Div. of Firestone Tire and Rubber Co. for cover gyroscopes, servo-actuators, and valves for Corporal.

## SYNOPSIS OF AWARDS

The following synopsis of government contract awards lists formally advertised and negotiated unclassified contracts in excess of $25,000 for each Air Force, Army, and Navy contracting office:

### AIR FORCE

**AF Cambridge Research Center, ARDC, USAF, Laurence G. Hanscom Field, Bedford, Mass.**

Research into the design features of a spectrographic telescope for stellar spectroscopy in the ultraviolet wavelength region to be undertaken from a satellite, $85,000, **Princeton Univ.,** Princeton, N.J.

Construction of balloon-borne particulate fractionator and platform, $49,970, **General Mills, Inc.,** 2003 E. Hennepin Ave., Minneapolis, Minn.

Investigation and development of circuitry on the falling sphere experiment, $57,075, **Univ. of Utah,** Salt Lake City, Utah.

Investigation of thin circular loop antennas and electronically scanned circular arrays, $45,000, **Univ. of Tenn.,** Knoxville, Tenn.

Preparation of high-purity elements by free radicals and organometallic compounds, $44,371, **Arthur D. Little, Inc.,** 30 Memorial Drive, Cambridge, Mass.

Research on infrared effects of clouds, fog, and haze, $29,652, **Scientific Planning Associates Corp.,** 7301 Birch Ave., Tacoma Park, Md.

Research directed toward the study of gases at auroral heights through spectroscopic studies with ion beams, $32,100, **Univ. of Arkansas,** Fayetteville, Ark.

Design and construction of specialized vacuum monochromators, $69,963, **Paul P. McPherson Precision Instruments,** 527 Main St., Acton, Mass.

Research in application of new mathematical techniques to the design and analysis of complex systems, $40,000, **Northwestern Univ.,** 360 Huntington Ave., Boston, Mass.

**AF Missile Development Center, ARDC, USAF, P.O. Box 393, Holloman AFB, N.M.**

Engineering services to maintain, modify, and overhaul liquid rocket sled system including required replacement parts, $28,092, **Coleman Engineering Co., Inc.,** 3500 Torrance Blvd., Torrance, Calif.

**Hq, AF Office of Scientific Research, ARDC, Washington 25, D.C.**

Continuation of basic studies in magnetohydrodynamics, $309,938, **Avco Research Div.,** Avco Mfg. Corp., 2385 Revere Beach Parkway, Everett 49, Mass.

Continuation of research on physics and chemistry of gases at high temperatures, $27,100, **Columbia Univ.,** New York 27, N.Y.

Continuation of research on information processes, $27,000, **Polytechnic Institute of Brooklyn,** 99 Livingston St., Brooklyn 1, N.Y.

Continuation of investigations of new particles and their interactions with nucleons, $98,860, **Johns Hopkins Univ.,** Baltimore 18, Md.

Continuation of a study of behavior and performance, $186,809, **Massachusetts General Hospital,** Boston, Mass.

Research on organometallic compounds of the Group III elements, $30,954, **Harvard College,** 10 Divinity Ave., Cambridge 38, Mass.

Continuation of research magnetic and structural properties of precipitating ferromagnetic systems, $25,909, **Franklin Institute,** Philadelphia 3, Pa.

Continuation of research on basic study of the energy exchange process between an electric arc and a gas flow, $96,000, **Plasmadyne Corp.,** 3839 S. Main St., Santa Ana, Calif.

Continuation of research on hypersonic flow characteristic in leading edges, $60,980, **MIT,** Cambridge 39, Mass.

Continuation of research on chemical reactions in shock waves, $35,958, **Brown Univ.,** Providence 12, R.I.

Continuation of technical review of biosciences research, $30,000, **Georgetown Univ.,** Washington 7, D.C.

Continuation of research on the electromagnetic acceleration of gas plasmas, $99,951, **Litton Industries of Calif.,** 336 N. Foothill Road, Beverly Hills, Calif.

Continuation of X-ray spectroscopic studies of the solid state, $60,000, **Cornell Univ.,** Ithaca, N.Y.

Research on development of arc-heated low-density wind tunnel, $40,000, **Univ. of Calif.,** Berkeley, Calif.

Continuation of research on early detection of microcracks resulting from fatigue of metals, $60,997, **Rutgers Univ.,** New Brunswick, N.J.

Research on heavy particle spectrometry, $46,639, **Franklin Institute,** 20th and Parkway, Philadelphia, Pa.

**Hq, Patrick AFB, ARDC, USAF, Patrick AFB, Fla.**

Increase in funds, $58,278, **Melpar, Inc.,** 3000 Arlington Blvd., Falls Church, Va.

Increase in funds, $43,257, **Houston**

**Fearless Corp.**, 11801 W. Olympic Blvd., Los Angeles, Calif.

### ARMY

**PURCHASING AND CONTRACTING DIV., WHITE SANDS MISSILE RANGE, N.M.**

Analog computer, $143,200, **Electronic Associates**, Long Branch Ave., Long Branch, N.J.

**U.S. ARMY ORDNANCE DIST., PHILADELPHIA, 128 N. Broad St., Philadelphia 2, Pa.**

Continuation of research and development on improved single base extruded propellants, $34,828, **E. I. duPont de-Nemours & Co., Inc.**, 1007 Market St., Wilmington 98, Del.

**U.S. ARMY ORDNANCE DIST., LOS ANGELES, 55 S. Grand Ave., Pasadena, Calif.**

Design studies, $48,960, **Northrop Aircraft**, Hawthorne, Calif.

Engineering research and development, $500,000, **California Institute of Technology**, 1201 E. California St., Pasadena, Calif.

Engineering services, $104,302, **Gilfillan Bros., Inc.**, 1815 Venice Blvd., Los Angeles 6, Calif.

Design and development $94,899, **Townsend Engineered Products**, Santa Ana, Calif.

Modification of guided missile equipment, $35,800, **Firestone Tire & Rubber Co.**, 2525 Firestone Blvd., Los Angeles 54, Calif.

**U.S. ARMY ORDNANCE DIST., ST. LOUIS, 4300 Goodfellow Blvd., St. Louis 20, Mo.**

Basic investigation related to environmental research, development, and evaluations, $72,464, **Southwest Research Institute**, 8500 Culebra Rd., San Antonio, Tex.

### NAVY

**OFFICE OF NAVAL RESEARCH, Washington 25, D.C.**

Research on the dynamics aspects of elastic and plastic buckling in structures and structural elements, $72,350, **Leland Stanford J. Univ.**, Stanford, Calif.

Research in surface propulsion systems, $29,705, **Douglas Aircraft**, El Segunda, Calif.

**U.S. NAVAL AVIONICS FACILITY, Indianapolis 18, Ind.**

Electronic analog computer and auxiliary components, $299,500, **Electronics Associates, Inc.**, Long Branch Ave., Long Branch, N. J.

## High-Temperature Coating For Molybdenum

A composite chromium-nickel coating for molybdenum, under study by D. E. Couch and associates at the National Bureau of Standards, resists oxidation for over 1000 hr at 980 C and for over 300 hr at 1100 C. This coated molybdenum is formed by electrodepositing nickel over chromium-plate.

## Isolation

(CONTINUED FROM PAGE 23)

is seen after an hour or two—for example, a "tunnel whose inside space seemed to be emitting a blue light." At the conclusion of this experience, the subject may feel that the day has started over, as if "he has just arisen from bed afresh."

Another series of experiments, reported by Wexler, et al., has produced "over-patterning" of sensory input. Their subjects lay in a respirator where they could hear only a monotonous drone from the motor. Again, disturbances in perception and thinking were common. It is worth noting that similar stimuli may be produced by internal equipment aboard a space vehicle.

Studies in our laboratory have been concerned with many aspects of this problem. Some experiments have reduced the total quantity of stimuli by using a dark, soundproof room. Others have altered the pattern of stimuli by frosted goggles and white noise. Still others have presented the subject with sensory patterns and tasks similar to those he may face during space flight.

The results of our investigations make it clear that isolation experiments involve far more than the quantity, modality, and pattern of physical stimuli impinging on the subject. His personality, motivation, and background, for example, strongly influence responses to experimental conditions. Other variables include the sense of separation, or "aloneness," the amount of communication, the degree of enclosure and confinement, and the type of activity permitted. Time is another important variable, since effects depend on the length, as well as the degree, of isolation. It has also been noted that subjects tolerate the experiment best when they know its duration or are allowed to terminate it whenever they choose.

Although reactions to isolation are varied, all subjects attempt to make the experience meaningful in terms of their accustomed world. For example, even when removed from most stimuli and given nothing to do, a military officer may structure the experiment as a mission and attempt to carry out what he views as his assignment.

To maintain a sense of continuity with previous experience, many subjects attempt to preserve their orientation in time. Others, seeking to maintain their spatial orientation, repeatedly check the position of the bed and refrigerator or assure themselves of "which way is North." If these efforts to hold on to a familiar frame

of reference fail, subjects frequently become anxious and terminate the experiment.

These findings suggest that the most important aspect of sensory deprivation is reduced information input, rather than reduced sensory input. It is not just the absence of physical stimuli which gives rise to difficulty, but the absence of data in which the subject is interested. Thus, a man in space will not be protected from the disruptive effects of sensory deprivation because he is exposed to a variety of clanging bells and flashing lights, but because he receives information which holds his attention and means something to him.

Results of isolation experiments, coupled with studies and accounts of solitary confinement, Arctic expeditions and survival experiences, suggest that the quantity and variety of information inputs to space crew members should be adequate for many weeks or months. Activities necessary for performance of the mission, recreational facilities and messages from earth, should thus prevent "sensory deprivation effects" in members of early expeditions.

Even with few of these advantages, the crew of Kon Tiki functioned effectively for more than three months in severely restricted quarters. Voyagers in the 15th and 16th centuries lived on ships scarcely larger than the vehicles envisioned for Martian expeditions. In thinking they were headed toward a sea monster-infested, boiling ocean, which might eventually end and pitch them into the void, these men were probably under greater emotional stress than future astronauts.

Nevertheless, decreased variation in sensory input may become a problem after many months or years. Mild forms of sensory deprivation can eventually produce adverse effects, just as they force women into periodic rearrangement of the living room furniture or drive some men to seek new jobs every few years. Since even the most varied experiences space vehicles can provide may become monotonous in time, this kind of restlessness will be a hazard for space crews.

It appears, then, that we face two problems. One is to provide a structured setting with ties to familiar customs and surroundings. The other is to duplicate, as well as possible, the diversity of experience possible in life on earth. This will be a task for those who select and train crews, as well as for those who develop their vehicles.

We must, for example, choose men who are comfortably identified with their society, without being overly dependent on conventional patterns of behavior. They must be capable of extended performance of routine duties, and at the same time have sufficient inner resources to ward off the stultifying effects of boredom. They must learn to respond predictably to all foreseeable situations without losing the ability to adapt flexibly to circumstances which cannot be foreseen.

The implications of this task extend into all areas of the behavioral sciences. Social psychologists, psychiatrists, neurophysiologists, and many others thus have a challenge to work with physical scientists in making space flight a reality.

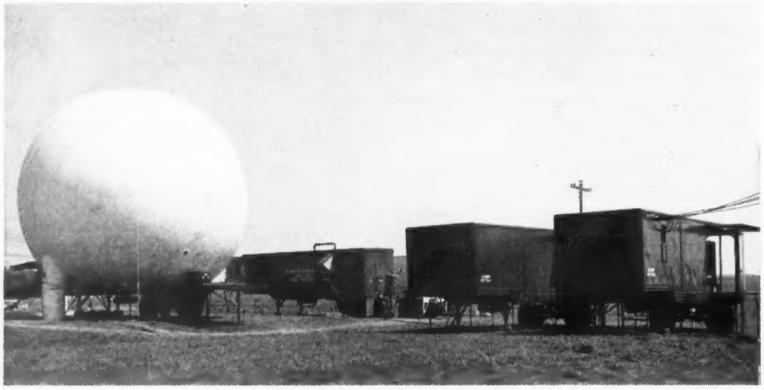
## High-Speed Ejection Simulated at Martin

**Parachute harness, life preserver and signal flares are part of integrated flying suit developed by The Martin Co.**

Recent Martin Co. wind tunnel ejection seat tests with life-size dummies as pilots have produced major advances in techniques for evaluating flight and survival equipment for pilots who must eject themselves from crippled high-speed aircraft. The tests, sponsored by the Navy, were conducted at the Arnold Engineering Engine Test Facility, Tullahoma, Tenn. Wind velocities above Mach 1 and compressible flow dynamic pressures of 2000 psf were simulated in the tests.

Martin engineers say the wind tunnel tests have proved superior in many respects to rocket sled testings. In a wind tunnel, they note variables associated with equipment undergoing high-speed ejection can be more closely observed and controlled.

# Frescanar, Eyes of Missile Monitor



**Shown deployed in the field, Frescanar, a frequency-scanning radar system developed by Hughes for the Army, employs a single 15-ton antenna.**

Missile Monitor, the over-all communication and fire control system being developed for Army field operations, including the launching of such missiles as Nike-Hercules and Hawk, incorporates a new narrow band, frequency-scanning radar which through one antenna gives simultaneous data on distance, bearing, and altitude of an aircraft or missile target. A digital computer programs the radiation pattern of the antenna for maximum coverage and accuracy. The radar system, known as Frescanar, was developed by Hughes Aircraft as an outgrowth of Navy sponsored research.

---

## Water Recovery

(CONTINUED FROM PAGE 35)

This process requires further development before satisfactory results can be achieved. It would be best for interplanetary flights, especially if auxiliary power is available and relatively large crews are utilized.

Processes involving a change in phase are efficient and can be simple, but require a relatively large amount of energy per pound of raw material to provide the latent heat of fusion and/or vaporization. For the first manned space vehicles, a water recovery system that requires no electrical power is desirable, since electrical power will be at a premium. The only other sources of thermal energy are solar radiation and heat losses from equipment and humans. It is thus to our advantage to conceive a change-of-phase system that utilizes these energy sources.

Change-of-phase processes also require the rejection of heat when condensation occurs. This is no problem since the condenser can be so situated that radiation to outer space occurs. This, of course, requires spaceship attitude control to keep the condenser on the side away from the sun.

In view of these design limits, let's look further at freeze drying. This technique has an advantage in that the raw material and recovered water can be handled in the solid state. To maintain this advantage, however, pressure and temperature within the recovery system must be less than the respective values at the triple point (3-mm Hg and approximately 20 F for urine). Thus, for every recovery cycle, the atmosphere within the system must be evacuated to space and condenser temperature maintained no higher than 20 F.

This temperature requirement indicates the minimum theoretical condenser area necessary to supply one man-day water requirement during a 12-hr recovery cycle. At 20 F, the latent heat of sublimation of water is 1219.3 Btu/lb. Radiation from a 20-F panel that has an emissivity of 0.90 is 84.7 Btu/ft$^2$-hr. Every square foot of condenser area, then, is capable of recovering 0.0695 lb/hr of water.

The atmosphere conditioning system would recover some 1000 gm of water from the lungs and skin. The water recovery system must thus reclaim 1200 gm to supply the 2200 gm required by a man. If wash water is used, the recovery system must recover 3000 of 3300 gm of contaminated water.

To recover this amount in 12 hr by freeze drying, without electrical power, requires at least 7.91 sq ft of condenser area for each man in the vehicle. This computation assumes that condenser heat transfer is the rate-determining criterion. In the actual case, processes of sublimation, diffusion, and condensation will affect this rate. Fortunately, for sublimation devices, these other processes are usually negligible in comparison to heat-transfer rate.

These computations indicate that relatively large condenser (radiation panel) areas are required to utilize a freeze-drying technique without electrical power. Smaller equipment could be realized by incorporating a refrigeration cycle, but this does not appear advantageous at the present time.

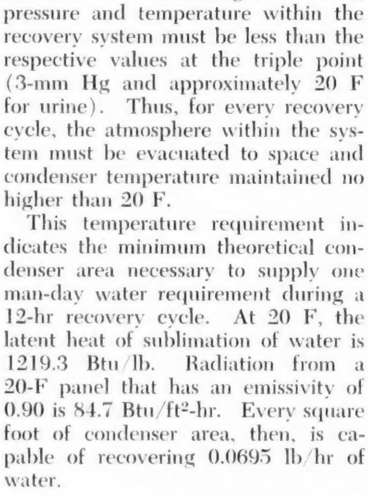
It appears we must turn to distillation. The internal temperature of manned space vehicles will be maintained near 70 F. Using a distillation process near this temperature is advantageous because no solar energy collecting device or electrical power is necessary. However, the raw mateial and recovered water must be handled in the liquid state.

If the condenser can be maintained near 70 F, the condenser area required to recover 3000 gm of water in 12 hr is 4.85 sq ft. This is a significant reduction over the area required for freeze drying.

Further reductions in condenser area could be realized by performing distillation at a higher temperature. However, higher temperatures cause more urea decomposition, as well as ammonia absorption in the recovered liquid. Also, the heat source must be at a higher temperature than the vehicle atmosphere, thereby necessitat-

---

# Precision Centrifuge to Test Titan Guidance Components



Made by Genisco of Los Angeles for American Bosch Arma, this laboratory centrifuge, which gives accelerations accurate up to one part in 100,000, is the first equipment capable of calibrating Titan inertial-guidance components. One end of its 20-ft long boom accepts a 16-in. cube weighing up to 50 lb for testing within this accuracy between 0.25 and 12 g.

ing complicated heating equipment. For our first water recovery systems, such a design appears inadvisable, especially since suitable equipment can be constructed that requires no electrical power, no complicated heating techniques, and a relatively small amount of vehicle surface area for condenser surface.

The drawing on page 35 illustrates a distillation water-recovery system of this kind which mounts on the wall of the vehicle. The back side of the box serves as a condenser, while the door acts as an evaporator. The major problem in developing a recovery system that utilizes distillation processes and no electrical power—how to handle the liquids in the absence of gravity, as well as residue remaining after removal of the water—is neatly solved with sponges.

The box is loaded by opening the door and removing the evaporator screen. Urine and wash-water saturated sponges are then placed in the evaporator cells. These sponges can be in a frozen state if the collection system can solidify human wastes, but this reduces the system capacity. The door is then swung into the condenser, and sealed with the aid of lock clamps.

#### Dumping Waste Odors

Removal of air from the system is advisable to dump waste odors overboard and to increase the rates of evaporation and diffusion. Air can be removed through a bleed valve.

During a 12-hr cycle, a small gradient in temperature and water vapor concentration will exist from the door to the condenser wall. At the condenser wall, the sponges, which are permeable, allow vapor to penetrate towards the wall and to condense there. As the sponges fill, the vapor condenses at greater distances from the wall. Recovery is completed when the average system temperature begins to drop rapidly.

By monitoring the condenser temperature, the space pilot can tell when to remove the sponges. If not removed at the right time, the recovered water would freeze within approximately 1 hr. Sponges with water frozen in them can, of course, be readily thawed in the space capsule.

Contaminated sponges can be reused or dumped overboard. By first using them to collect drinking water, then wash water, and finally urine, the sponges can be used at least three times before becoming completely saturated with contaminants. The recovery sponges can be adapted to contain activated charcoal, a sterilization agent, or a washing agent.

This water-recovery system appears efficient, lightweight, and inexpensive—in short, practical. Slightly more elegant in engineering detail than illustrated, it could well prove the answer to the water economy of spaceships traveling a few days or weeks.

### Purolator Moving into Rocket Fuel Filtration Field

Purolator Products, Inc., has moved into the rocket fuel filtration field, and is now offering a line of filters for rockets, guided missile, aircraft, and other industrial applications through a newly formed division headed by Jules Kovacs, vice-president in charge of technical sales.

Using specially formed metal-edged ribbon-type metal, porous metal fibers and powders, fabrics, synthetics, absorptive and adsorptive materials, as well as combinations of such materials, Purolator has already developed filters which can remove solid $CO_2$ particles from lox, to resist the effects of red fuming nitric acid and other oxidizers used with exotic fuels, and to withstand shock and vibrations up to 130 g.

For some applications, filters are designed to operate at temperatures from −420 to 1500 F, at pressures from near vacuum to 10,000 psi, and at degrees of filtration ranging from 0.3 to 500 microns.

To expand applications of the new filters, the company has organized a group of filtration specialists equipped to design specific items of equipment for operating conditions met in different industries.

### Space Gem

**Looking ready for outer space, this little poppet and seat of artificial sapphire, made by Linde Co., will be used in a valve to relieve pressure in the tank of a space vehicle. Sapphire has good dimensional stability and withstands hammering against a metal surface without scratching over a wide temperature range. Parts such as the poppet thus keep leakage to a minimum.**

## Missile Market

(CONTINUED FROM PAGE 46)

cannot guarantee successful investment, but is rather one of the many tools that the investor can use to determine whether or not he is getting his money's worth. Also, all other things being equal, it establishes for him a range of acceptable market prices for a given issue.

A yearly growth rate of 15 per cent (earnings doubling in five years) could command a market price of 20–30 times present earnings, while 20 per cent and up (doubling of per-share earnings in four years or less) can see prices of 30–40 times the company's yearly earnings.

Great emphasis should be placed, of course, on future *per-share* earnings, since dilution of equity through additional financing can hold these down even though the company's net income in dollars shows the required upward movement.

A further danger to investors is too great a reliance on historical performance as a basis for establishing the price-earnings relationship. If a company has doubled its earnings in the 1954–58 period and is selling at 25 times 1958 earnings, it would be wise to investigate whether it can be expected to repeat this performance by 1962. If it looks doubtful that earnings can double again in the next five years, the present P-E ratio may be only a relic of past performance, and the market price may be too high for current purchases. Similarly, investors should not retain their commitments in companies which have performed well but whose growth is over (or will continue only at a reduced rate) and have failed to recognize the change in expected rate of growth for the future, even though the P-E ratio may still be high.

## World Congress of Flight

The First World Congress of Flight, which will include the Fourth Annual Jet Age Conference of the Air Force Association, will be held at Convention Center in Las Vegas, Nevada, April 12–19. The Congress will be devoted to the global impact of intercontinental commercial jet transport, commemoration of the 10th anniversary of NATO, and results of the IGY.

## New ACS President for 1960

The American Chemical Society has chosen Albert L. Elder, director of research for Corn Products Refining Co., Argo, Ill., as its president-elect. He will head the society in 1960.

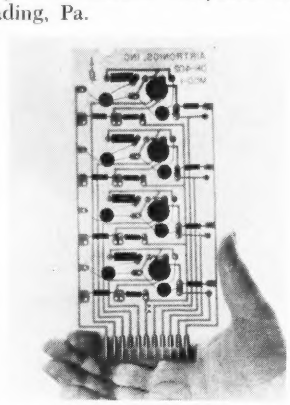
# New equipment and processes

**Liquid Nitrogen Generator:** System provides a nitrogen liquifying facility for industrial and laboratory users who have moderate needs. In operation, the blower of the nitrogen column supplies oil-free air at a slight positive pressure. Arthur D. Little, Inc., 20 Acorn Park, Cambridge 40, Mass.

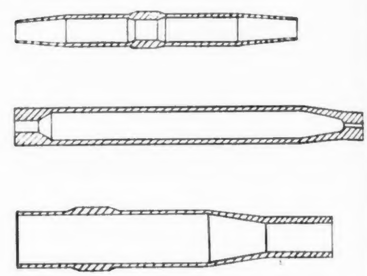
**Three-Dimensional Cams:** High precision cams which withstand shock, vibration and other severe environmental conditions, producing an output motion determined by two input variables, have been added to the AMCAM line of Brown & Sharpe, Swiss-type and special two dimensional cams. American Cam Co., Box 2106, Hartford, Conn.

**Teflon O-Rings:** "Mirror Finish" o-rings for applications subject to high temperatures, are impervious to oils, solvents, hydraulic fluids, acids and corrosive chemicals. The low coefficient of friction of the rings in many cases eliminates need for external lubrication. Chicago Gasket Co., 1271 North Ave., Chicago, Ill.

**Beryllium Oxide Shapes:** High purity hot-pressed and machined beryllium oxide shapes in blocks up to 12 in. in diam and 6 in. high are now in production. They can be machined with extremely close tolerances into building blocks for use in precisely designed assemblies. Beryllium Corp., Reading, Pa.



**Power Pulser:** DK 402 Mod 1 is a fully transistorized high current magnetic memory driven with current pulses up to 400 milliamp. Each pulser is capable of switching its maximum load for 10 microsec at a 20 kc repetition rate at 25 C ambient. Airtronics Inc., 5522 Dorsey Lane, Bethesda, Md.



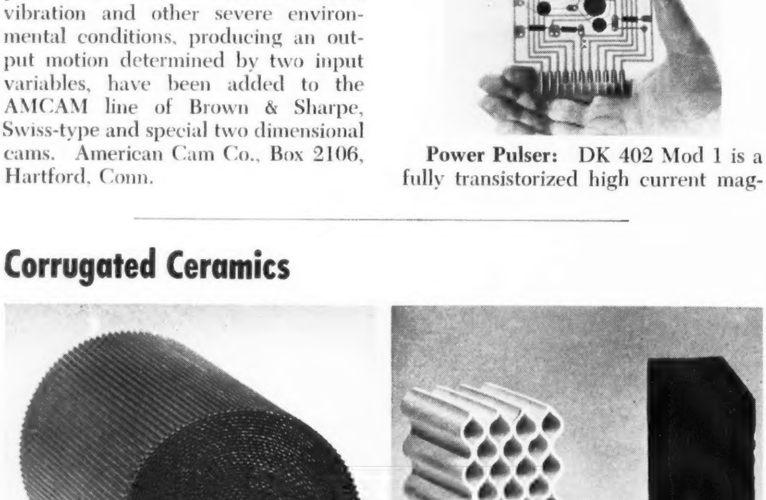
**Metal Gathering and Flotrusion:** Tubular parts and components in a wider range of shapes and sizes can now be made simply within precise design limits by new techniques—metal gathering and flotrusion—used separately or together. Components can be produced as an integral piece of metal, eliminating the need for end fittings, welding or brazing. Metals adaptable to the process include alloy steels, aluminum, titanium and zirconium. Some metals already heat-treated may be processed, thus adding greater strength. Tapco Group, Thompson Products, Inc., 8354 Wilcox Ave., Bell, Calif.

**Dynamic Load Tester:** Designed to handle 225 tons and checked to cycle regularly up to 150 tons, one of the largest testers for hydraulic equipment has been installed at Regent Jack Mfg. Co. The self-contained unit has a height clearance of 17 ft under the ram, allowing testing of all aircraft jacks currently in use. Regent Jack Mfg. Co., Downey, Calif.

**Split-Wedge Transducer:** Model 2562 vane transducer provides angle-of-attack information at all speeds and altitudes throughout a wide operational range. It consists of a heated, split-wedge vane, geared to two output synchros. Damping is maintained at 0.5 of critical by a viscous-type damping mechanism. Recovery time for 63 per cent of a step input at 110 knots is only 0.075 sec, and sensitivity is 0.2 deg from 90 to 125 knots and 0.1 deg from 125 knots to Mach 3. G. M. Giannini & Co., Inc., 918 E. Green St., Pasadena 1, Calif.

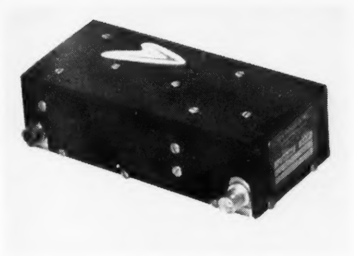
**Telemetry Transmitter:** Miniaturized FM transmitter Type 1004A provides true frequency modulation across the standard IRIG telemetry channels

## Corrugated Ceramics



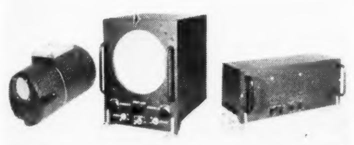
**Samples of corrugated ceramics. At left, Mg-Al silicate 0.002 in. thick in modular heat-exchange column of 2 in. diam; at right, zirconium oxide (left) and bonded silicon carbide structures each 2 in. high.**

Certain ceramics, announced the Minnesota Mining and Manufacturing Co., can now be formed as thin corrugated sheets and other large-surface structures, permitting for the first time production of ceramic heat exchangers, catalyst carriers and structures like honeycomb. Ceramic structures of this kind, because of their high temperature resistance, should find application in missiles, space vehicles and nuclear reactors.

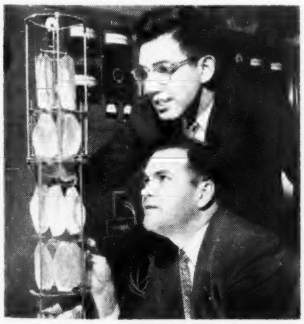


covering the frequency band of 215 to 260 mc. Modulation is obtained by impressing the input signal through a semiconductor circuit. Nominal output is 5 watts, weight 22 oz. Tele-Dynamics, Inc., 5000 Parkside Ave., Philadelphia 31, Pa.

**Semiconductor Switch:** A slight change in voltage actuates (avalanche effect) an aluminum-silicon junction switch in about 50 trillionths of a sec (calculated). This device, now under development, should advance computer technology for guiding missiles and space vehicles. Sperry Semiconductor Div., Sperry Rand Corp., South Norwalk, Conn.



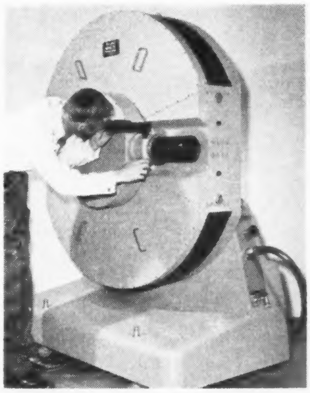
**Military TV System:** Weighing 55 lb, the MTS-4 military television system makes possible closed-circuit tv within military aircraft, ships, and vehicles. It consists of a tv camera, control unit, and monitor, all transistorized. Dage Television Div., Thompson Ramo Wooldridge, Inc., Michigan City, Ind.



**Synthetic Quartz:** Crystals with $2^1/_2$ times the yield of natural quartz are now being grown economically at a rate of 0.060 in. per day in pilot production. These crystals have natural faces, which allow easier orientation of the stock for cutting, and no foreign inclusions. Western Electric Co., Inc., Merrimac Valley Works, N. Andover, Mass.

**Silicon Transistors:** Six types of vhf silicon power transistors are now available—three 70-mc oscillator and three 70-mc amplifier transistors. Each group has power capabilities of $^1/_4$, $^1/_2$, and $^3/_4$ watt output, permitting operation at collector voltages up to 100 vdc. Pacific Semiconductors, Inc., 10451 W. Jefferson Blvd., Culver City, Calif.

**High-Temperature Lubricant:** With an effective operating range of −100 to 600 F, Grease H exceeds proposed specification MIL-G-25013C for temperature range and hours of service. Shell Oil Co., Industrial Products Dept., 50 W. 50 St., New York 20, N.Y.



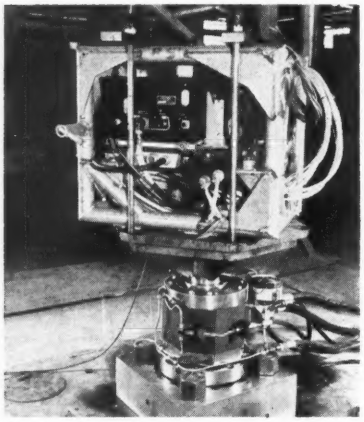
**Framing Camera:** Recording eighty-two 35-mm frames in 55 microsec, the Model 192 continuous-writing framing camera accommodates magnification-velocity products up to 3 mm per microsec. At conventional magnification, the camera accommodates object velocities to Mach 35. Beckman & Whitley, Inc., 985 E. San Carlos Ave., San Carlos, Calif.

**Pressure Relief Valve:** Designed for rocket applications, this valve, which weighs 0.04 lb and is $^3/_{16}$ in. in line size, will handle pressures to 1000 psi at temperatures to 1800 F. Generally used in gas-generator combustion chambers, it can be adapted to auxiliary-power or main-propulsion systems. Aero Supply Mfg. Co., Carry, Pa.

**Current-Integrating Electrometer:** Model AE1-101 electrometer, first designed for particle-accelerator beam-current integration, can be applied to industrial control and instrumentation systems. In chemical processes it can be used to measure total amounts of ions in solution. The current meter reads plus or minus currents in the range $5 \times 10^{-10}$ to $1 \times 10^{-3}$ amp, full scale. Applied Radiation Corp., 2404 N. Main St., Walnut Creek, Calif.

**Fast-Switching Transistors:** In

commercial production, the 2N559 germanium transistor gives switching speed into the millimicrosecond range and typical alpha-cutoff frequency of 250 mc. It is rated to dissipate in excess of 150 mw in air, and will operate at temperatures up to 100 C. Texas Instruments, Inc., P.O. Box 312, Dallas, Tex.



**Vibration Tester:** The Model W-2000 Hydrashaker has a force output of 24,000 lb and operates at frequencies up to 2000 cps. It can test components for rocket-powered vehicles like the X-15. Wyle Associates, 128 Maryland St., El Segundo, Calif.

## LITERATURE

**Fabrication of Laminated Plastics and Vulcanized Fibre Parts.** Taylor Fibre Co., Norristown, Pa.

**Aircraft and Missile Accessories,** Bulletin F5910-1. Barber-Colman Co., 1400 Rock St., Rockford, Ill.

**Microwave Target Generator,** A Pre-flight Radar Tester. Remanco Inc., 128 Broadway, Santa Monica, Calif.

**Teflon Hose and Related Products,** Catalog 103. Aeroquip Corp., Jackson, Mich.

**Battery and Power Connectors,** Catalog GB-7-2958. Cannon Electric Co., 3208 Humbolt St., Los Angeles 31, Calif.

**Miniature Connectors,** Catalog KM-1. Cannon Electric Co., 3208 Humbolt St., Los Angeles 31, Calif.

**Strain-Gauge Pressure Transducers,** Bulletin PSG-1. Glennite Instrumentation Div., Gulton Industries, Inc., Metuchen, N.J.

**Explosive Valves and Latch Pins,** Catalog 5808-XV. Conax Corp., 2300 Walden Ave., Buffalo 25, N.Y.

**Aluminum-Lightweight RF Coaxial Connectors,** Catalog ALRF-1. Cannon Electric Co., 3208 Humbolt St., Los Angeles 31, Calif.

**Series 21 Low-Flow Servo Valves,** Catalog 210. Moog Valve Co., Inc., E. Aurora, N.Y.

**Midget Valves and Fittings,** Catalog 658. High Pressure Equipment Co., Inc., 1222 Linden Ave., Erie, Pa.

**Thermocouple Assemblies and Pressure Sealing Glands,** Catalog 1885. Conax Corp., 2300 Walden Ave., Buffalo 25, N.Y.

**Nylined Bearings and Nyliners,** Bulletin 209. Thompson Industries, Inc., Manhasset, L.I., N.Y.

**Pressure Switch Data,** Folder CEI-602. Century Electronics & Instruments, Inc., 1333 N. Utica, Tulsa 10, Okla.

**Quick Coupling Assemblies,** Catalog F-10-R. Jordan Industrial Sales Div., OPW Corp., 6013 Wiehe Rd., Cincinnati, O.

**Transistor Servo Amplifiers,** Bulletin 501-2 Librascope Inc., 808 Western Ave., Glendale 1, Calif.

**Transistor Fundamentals and Applications,** Booklet 4T37. RCA, 50 Rockefeller Plaza, New York 20, N.Y.

**Silicon Photo-Voltaic Readout Cells,** Bulletin 33-58. Semiconductor Div., Hoffman Electronics Corp., 930 Pitner Ave., Evanston, Ill.

**Microwave Ferrite Devices.** Sylvania Electric Products Inc., 1100 Main St., Buffalo, N.Y.

**Utility Packaged Amplifier.** George A. Philbrick Researchers, Inc., 285 Columbus Ave., Boston 16, Mass.

**Transformers and Related Magnetic Components** Minitran Corp., 5 Oliver St., Newark 2, N.J.

**Servoboard Electromechanical Assembly,** Catalog TDS-1110-1. Servo Corp. of America, 20-20 Jerico Turnpike, New Hyde Park, L.I., N.Y.

**Reactive Metals and Super Alloys Handbook for Pipe and Tubing.** Damascus Tube Co., Greenville, Pa.

**Ductile Vanadium.** Vanadium Corp. of America, 420 Lexington Ave., New York 17, N.Y.

**Capillary Tubing.** Superior Tube Co., Germantown Ave., Norristown, Pa.

**Selection and Application Guide for Tubing,** Bulletin 41. Superior Tube Co., Germantown Ave., Norristown, Pa.

**Special Alloy Welded Tubing and Pipe** Bulletin TD 125. Carpenter Steel Co.. Alloy Tube Div., Union, N.J.

**Small Diameter Beryllium-Copper Tubing,** Memorandum 7. Superior Tube Co., Germantown Ave., Norristown, Pa.

**Tubular Products.** J. Bishop & Co., Malvern, Pa.

**Platinum, Platinum-Rhodium Thermocouple Wire,** Bulletin TC-2. J. Bishop & Co., Malvern, Pa.

**Standard Deep-Drawn Aluminum Boxes and Covers,** Catalog B. Zero Manufacturing Co., 1121 Chestnut St., Burbank, Calif.

**Drafting Standards.** Reprint of article on standards for microfilmed engineering drawings used by Bell Telephone Labs. The Filmsort Co., Pearl River, N.J.

**Measurement and Control,** a summary brochure on shock, vibration, pressure and temperature. Gulton Instrument Div., 212 Durham Av., Metuchen, N.J.

**Plastics Reference,** a 132-page summary of thermoplastic materials and properties. Boonton Molding Co., Boonton, N.J.

**Carbon and Graphite,** Properties and Applications, a 56-page manual (Catalog 40B). Stackpole Carbon Co., St. Marys, Pa.

**Radiating Systems.** Engineering data and installation drawings on antennas, switches, dividers, filters and other components. Bulletin RS 100. Electronic Specialty Co., 5121 San Fernando Rd., Los Angeles 39, Calif.

**Stainless Steels.** Uses, physical characteristics, and weight-estimating tables for Micro-Rold special-purpose stainless steels. Washington Steel Corp., Washington, Pa.

**Electronic Hardware.** Reference manual of standard electronic hardware for use in design and purchasing. Reference data is conveniently tabulated. Amatom Electronic Hardware Co., Inc., 88 Drake Ave., New Rochelle, N.Y.

**Temperature Detectors.** Catalog EN-84 gives information on Thermohm detectors (resistance thermometers for temperatures up to 1000 F). F. Leeds & Northrup Co., 4934 Stenton Ave., Philadelphia 44, Pa.

**Mach Charts.** Mach number compared with altitude and temperature. G. M. Giannini & Co., Inc., Pasadena, Calif.

**Vibration Mountings.** Product Bulletin 710 engineering data on shock and vibration mounts for electronic equipment. Lord Mfg. Co., Erie, Pa.

**Connectors.** Catalog of pressurized and waterproof plugs and receptacles, cable clamps and tubing clamps. H. H. Boggie, Inc., Box 817, Toledo, Ohio.

**Special Hazard Fire Protection.** Methods for protection, including water spray, foam, carbon dioxide and dry chemical. Grinnell Co., Inc., 260 W. Exchange St., Providence 1, R.I.

**Rectifiers.** Rectifier News (RN-658) contains application data on various rectifier types. International Rectifier Corp., El Segundo, Calif.

**High-Pressure Check Valves.** Technical bulletin V-158 gives installation dimensions and charts on flow characteristics for water and gas. Precision Equipment Co., Inc., 1740 Crenshaw Blvd., Torrance, Calif.

**Upper-atmosphere vacuum spectrum chart.** National Research Corp., 70 Memorial Drive, Cambridge 42, Mass.

**Charting space.** The Garrett Corp., Los Angeles, Calif.

**Radar data processing for Sage.** Burroughs Corp., Detroit 32, Mich.

**UNIVAC II data processing system.** Remington Rand Univac, Div. of Sperry Rand Corp., 315 Fourth Ave., New York 10, N. Y.

**Cryogenics, nuclear engineering, high-pressure systems.** The Stearns-Roger Mfg. Co., Denver, Colo.

**Data processing and computation.** General Electric, Missile and Space Vehicle Dept., 3198 Chestnut St., Philadelphia 4, Pa.

**Nuclear equipment.** General Mills, 1620 Central Ave., Minneapolis, Minn.

**Norelco X-ray instrumentation.** Philips Electronics, Inc., 750 S. Fulton Ave., Mt. Vernon, N. Y.

**Microscope accessories.** Bausch & Lomb Optical Co., Rochester 2, N. Y.

**Indicating dial thermometers.** American Machine and Metals, Inc., U.S. Gauge Div., Sellersville, Pa.

**High-temperature thermocouple probe.** Thermo Electric Co., Inc., Saddle Brook, N. J.

**Glass fiber insulation.** LOF Glass Fibers Co., 1810 Madison Ave., Toledo 1, Ohio

**Image converter camera.** Librascope, Inc., 66 South P St., Livermore, Calif.

**Vibration test systems.** MB Mfg. Co., 781 Whalley Ave., New Haven 8, Conn.

**Lateral-controlled-motion vibration tester.** L. C. Miller Co., 5005 E. Slauson Ave., Los Angeles 22, Calif.

**Systems silencing.** Koppers Company, Inc., Baltimore 3, Md.

# Frontiers are extended by the practical visionary

It is the practical visionary who has given us much of what we enjoy today. And it will be the visionary—the man with ability to seek concepts beyond the existing limitations of science—who will guide our developments of tomorrow.

The Applied Physics Laboratory (APL) of The Johns Hopkins University seeks men who will be engaged in advanced research problems—who will find solutions to problems yet to be posed. Their findings will provide guidelines for the space and missile hardware research of the future.

Your endeavors will be heightened by the professional atmosphere of APL. This atmosphere, created by men dedicated to the furtherance of science, has earned APL a reputation as a leader in programs vital to the national security.

*Appointments at APL offer exceptional opportunities. For detailed information, address your inquiry to:*
**Professional Staff Appointments**

## The Johns Hopkins University Applied Physics Laboratory

8609 Georgia Avenue, Silver Spring, Maryland

**Shock testers.** Consolidated Electrodynamics Corp., Rochester 3, N.Y.

**Modern force measurement.** Baldwin-Lima-Hamilton Corp., Waltham 54, Mass.

**Continuous stream analyzers.** Beckman Instruments, Inc., 2500 Fullerton Rd., Fullerton, Calif.

**Spectrographs.** Bausch & Lomb Optical Co., Rochester 2, N.Y.

**Dilatation interferometers.** Gaertner Scientific Corp., 1201 Wrightwood Ave., Chicago 14, Ill.

**The contact modulator: Part I—Why Use Choppers?** The Airpax Products Company, Jacktown Rd., Cambridge, Md.

**Ground current conduction.** Aronson Machine Co., Arcade, N.Y.

**Missile plug for manned aircraft.** Cannon Electric Co., P.O. Box 3765, Terminal Annex, Los Angeles 54, Calif.

**Threaded miniature coaxial connectors.** General RF Fittings, Inc., 702 Beacon St., Boston 15, Mass.

**Plug systems and facilities.** Cannon Electric Co., 3208 Humboldt St., Los Angeles 31, Calif.

**Plastic-insulated and jacketed control cable.** Chester Cable Corp., Chester, N.Y.

**1000 F flexible wire.** Hitemp Wires Inc., 1200 Shames Dr., Westbury, N.Y.

**Germanium diodes.** Ohmite Mfg. Co., 3601 Howard St., Skokie, Ill.

**Thermostatic controls and devices.** Stevens Mfg. Co., Inc., Lexington and Mansfield, Ohio.

**Trimpot trimit.** Bourns Laboratories, Inc., Riverside, Calif.

**Precision components for computers, instruments and control systems.** Ford Instrument Co., Div. of Sperry Rand Corp., 31-10 Thomson Ave., Long Island City 1, N.Y.

**Heavy-duty limit switches.** Micro Switch, Div. of Minneapolis-Honeywell Regulator Co., Freeport, Ill.

**High-performance balanced vane pumps.** Vickers Inc., Detroit 32, Mich.

**Resistance bridge indicator.** Datran Electronics, 1836 Rosecrans Ave., Manhattan Beach, Calif.

**Glennite ceramic transducers.** Gulton Industries, Inc., Metuchen, N.J.

**Model 60 solid-state electronic chopper.** Solid State Electronics Co., 8158 Orion Avenue, Van Nuys, Calif.

**60-cycle motor generators.** Kearfott Co. Inc., Little Falls, N.J.

**AC generators.** Kato Engineering Co., Mankato, Minn.

**Power transmission equipment.** T. B. Wood's Sons Co., Chambersburg, Pa.

**Automatic PDM-to-digital computer format data-reduction system.** Epsco, Inc., 588 Commonwealth Ave., Boston, Mass.

**High-speed translation of electronic impulses.** Burroughs Corp., Detroit 32, Mich.

**Hydro-pneumatic transfer barrier accumulators.** Greer Hydraulics, Inc., New York International Airport, Jamaica 30, N.Y.

**Synchronous motors.** Electric Indicator Co., Inc., Camp Ave., Stamford, Conn.

**Quality servo motors.** Norden, Commack, Long Island, N.Y.

**Ground support accessories.** Frebank Company, 711 W. Broadway, Glendale 4, Calif.

**Antennas, antenna systems, transmission lines.** Andrew Corp., Claremont, Calif.

**Solder terminals.** Alpine Electronic Components Inc., Waterbury, Conn.

**Truarc retaining rings.** Waldes Kohinoor, Inc., 47-16 Austel Place, Long Island City 1, N.Y.

**Finger-flexible teflon hose.** Titeflex, Inc., Springfield, Mass.

**Hastelloy alloy B.** Haynes Stellite Co., Kokomo, Inc.

**Fans and blowers for electronic applications.** McLean Engineering Laboratories, Princeton, N.J.

**Color code system.** Crown Industrial Products Co., Woodstock, Ill.

**Zero military transit, combination, instrument cases.** Zero Mfg. Co., 1121 Chestnut St., Burbank, Calif.

**Graphex, coprex and woodex oilless and self lubricating bearings, bushings, machine parts** Wakefield Bearing Corp., 29-99 Foundry St., Wakefield, Mass.

**Standard instrument cases.** TA Mfg. Corp., 4607 Alger St., Los Angeles 39, Calif.

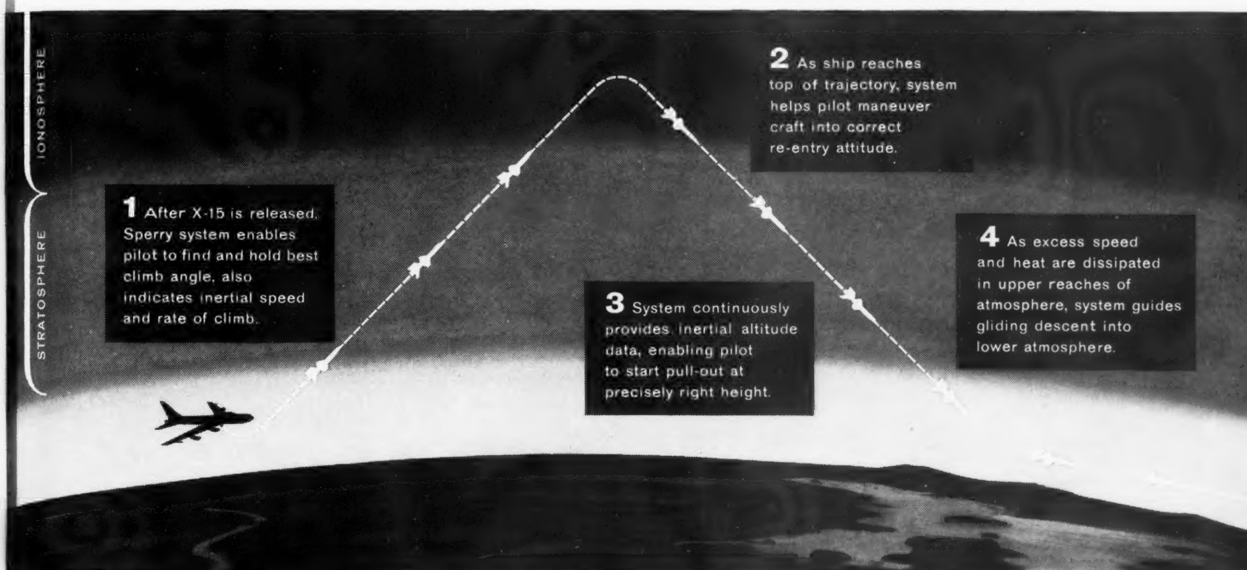
---

## New Lightweight Lox Converters

Exceeding all MIL specs, this 25-liter Lox converter (ME-3), now being produced by Linde for the latest model B-52, weighs only 40 lb and fits in a space 19 in. high and 20 in. in diameter. The tank consists of concentric aluminum and stainless-steel shells separated by an annular vacuum and a special insulation, which, in the event of a leak in the aluminum outer shell, prevents rapid loss of Lox. Under normal conditions the ME-3 will supply enough oxygen to sustain four men for 30 hours at altitudes above 35,000 ft. It can deliver more than 150 liters of gaseous oxygen per minute at operating pressure of 300 psig. Linde has in the final testing stages a 10-liter converter. These converters can be adapted for nitrogen pressurization.


**HYPERSONIC X-15,** powered by a mighty rocket engine, will follow bullet-like trajectory during flight, similar to path of ballistic missile.

**WEARING SPECIALLY-DESIGNED SPACE SUIT,** X-15 pilot is protected against environmental extremes as he maneuvers the rocket to the edge of space.




# X-15 WILL THRUST 100 MILES INTO SPACE UNDER CONTROL OF NEW INERTIAL SYSTEM

Strapped firmly into his cockpit, an Air Force pilot soon will ride the North American X-15 rocket research ship 100 miles and more into the sky at speeds above 3600 mph—over a mile a second.

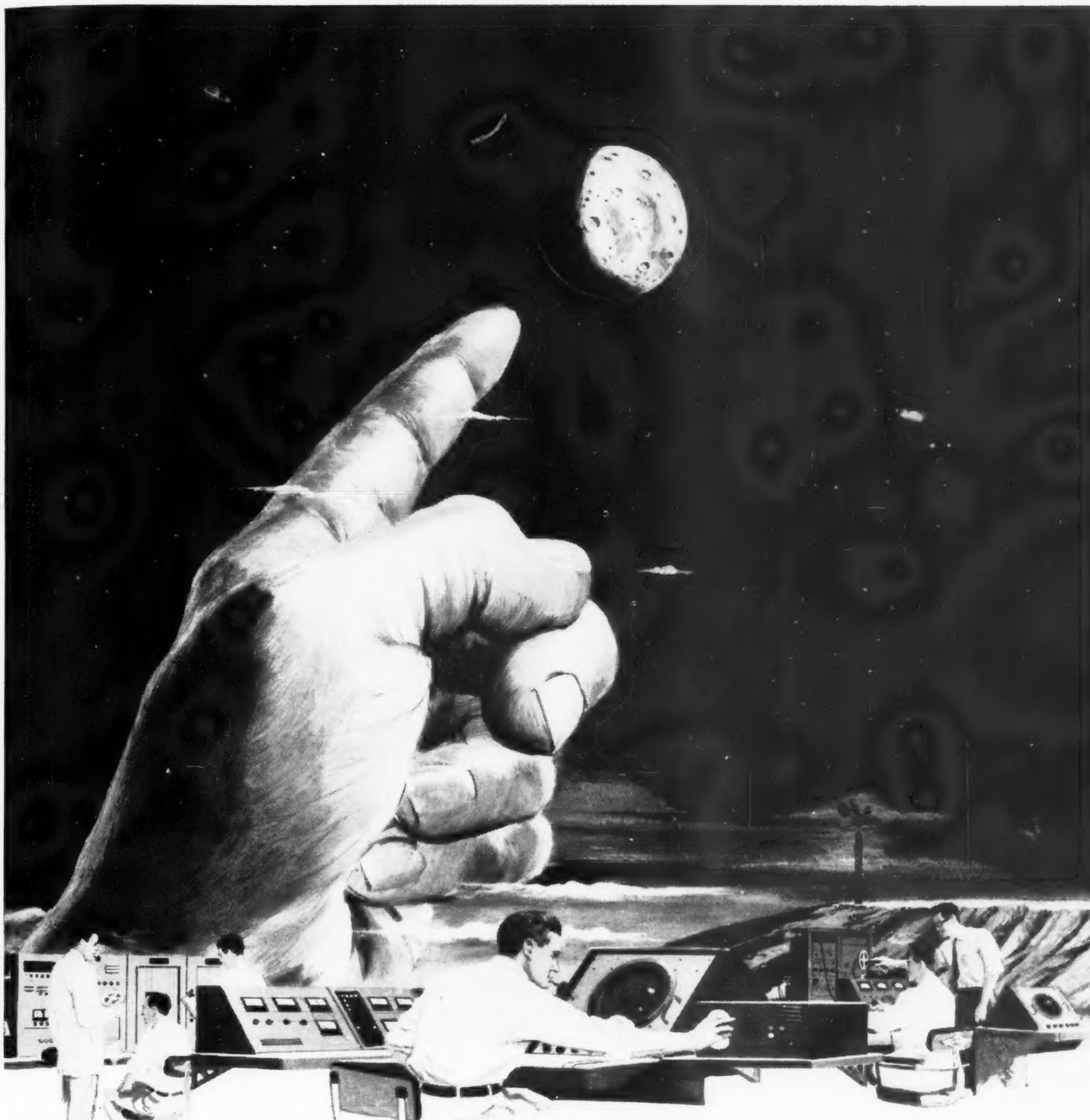
A highly advanced Sperry inertial system, developed in conjunction with the Flight Control Laboratory of Wright Air Development Center, will supply control data for this historic venture. When the pilot and his revolutionary craft drop from a B-52 jet bomber, the inertial system will give him data for maneuvering and navigating the X-15 with extreme accuracy. As the stainless steel research plane flashes outward through the thinning atmosphere, the Sperry system will "show" the pilot how to correct for even the smallest deviation from flight path. It will display flight information on specially developed instruments; at the same time feeding the data to ground and airborne recorders for a permanent record of the flight.

An important additional contribution of the Sperry system will be to guide the pilot in bringing the X-15 safely back into the earth's atmosphere. During this critical phase of the flight, attitude of the X-15 on re-entry must be precisely controlled to avoid exceeding its structural limitations.

On this daring journey into space, the super-sensitive Sperry system will have to function perfectly under conditions ranging from extreme acceleration to complete weightlessness, through temperature swings that may heat the X-15's exterior to 1,000 degrees in a few seconds.

**SPERRY** *GYROSCOPE COMPANY*
*Great Neck, New York*
*DIVISION OF SPERRY RAND CORPORATION*

# Index to Advertisers



# An advanced concept

*The Singer Manufacturing Company announces the formation of its Military Products Division. which through its three functional units, Haller, Raymond & Brown, Inc., Diehl Manufacturing Company, and Singer Bridgeport Division, can efficiently handle complex electro-mechanical and electronic programs from concept to completion.*

SINGER *

MILITARY PRODUCTS DIVISION

**THE SINGER MANUFACTURING COMPANY**

**Military Products Division**

149 BROADWAY, NEW YORK 6, N. Y.

*A TRADEMARK OF THE SINGER MANUFACTURING COMPANY